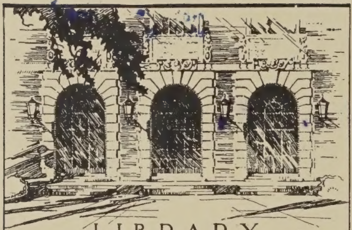

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THE MAGIC LANTERN

AND

ITS APPLICATIONS.

BY

L. H. LAUDY, PH.D.,

School of Mines, Columbia College, New York.

WITH FORTY-SEVEN ILLUSTRATIONS.

New York:

E. & H. T. ANTHONY & CO., PUBLISHERS.

1886.

PREFACE.

IN presenting this little work to the public, the author has endeavored to embody in as concise a form as plain language would admit, a thoroughly practical description of each of the more important lanterns and accessories that have come under his personal observation during some fourteen years of practice connected with the School of Mines, Columbia College.

It is hoped that it may meet with approval, be of assistance to those who are in search of a work on the subject of lantern projections, and enable them, with a little practice, to meet the many demands made upon them.

No better gift, whether the toy lantern or the more perfect instrument, can be selected, for it is certain to please, is well qualified to convey instruction with the most gratifying results, and it can be applied to a variety of useful, instructive, and eminently attractive purposes. With the aid of photography, geography, and allied sciences, natural history and extended travel to all parts of the earth can be enjoyed without expense and fatigue, and with a degree of accuracy unknown till its introduction; and to its utility in this direction no limits can be assigned. Need more be said in its favor? I think not; for it will commend itself to every careful and thoughtful mind, and it is to be hoped that its introduction may be more general in the household, where it will be looked upon with the same importance as is a library for imparting useful knowledge.

In a treatise such as this, it is impossible to enlarge upon all that has been done in advancing to the degree of perfection in which we find the lantern today. My object has been to give a simple and in some cases brief description of each lantern, and in so doing to call attention to the most important points in connection with their history and application. Much has of necessity been omitted for want of space and time, but I hope that what has been written may lead to a better understanding, awaken an interest in many of my readers, and meet with a kind reception at their hands. Having now completed my task, I take this opportunity to express my thanks to Dr. A. H. Elliott, the Associate Editor of *Anthony's Photographic Bulletin,* for his patience and valuable assistance while writing this brochure; and my thanks are also due to the publishers for the great care which they have bestowed upon the illustrations.

If my efforts meet with approval, no one will be more pleased than the author.

L. H. LAUDY.

NEW YORK, May, 1886.

TABLE OF CONTENTS.

CHAPTER I.

PAGE.

INTRODUCTORY 3

CHAPTER II.

THE CONSTRUCTION OF THE LANTERN 6

CHAPTER III.

THE SOURCES OF ILLUMINATION 11

CHAPTER IV.

SIZE OF LANTERN—CARRIERS—DISSOLVERS 15

CHAPTER V.

VARIOUS FORMS OF LANTERNS 19

CHAPTER VI.

SCREENS—SLIDES—MANAGEMENT OF LANTERN 27

CHAPTER VII.

VERTICAL LANTERN—MICROSCOPE ATTACHMENT—SPECTRUM PROJECTORS 34

CHAPTER VIII.

ATTACHMENTS FOR POLARIZED LIGHT 43

CHAPTER IX.

A NEW APPARATUS FOR THE OXY-CALCIUM LIGHT 47

The Magic Lantern and its Applications.

CHAPTER I.

INTRODUCTORY.

If we divide our senses into four integral parts, we at once find that by far the most important is that of sight. The sense of touch extends to objects only within our reach ; that of smell must be close to us ; and of hearing the limit is small for the loudest sound to reach us.

Seeing is eminently far in advance of all our senses, and by its means the external world is communicated to the internal brain through the medium of the optic nerve; and, subjectively, impressions are thus produced from the retinal images, which are reflections of external objects brought within the field of view. The eye is privileged to extend far beyond the limits of this little world and to view the immensity of the starry universe.

The unaided eye sees but little of creative power, for there is a world hidden from our view which would have remained unknown had not modern science discoverod the microscope and revealed this land of minute forms.

Such was the globe of water, magnifying the objects in distorted forms, till in the hands of science it sprung into that exquisite refinement of optical knowledge, the microscope.

The kaleidoscope was long regarded as a wonder and toy, until in practical hands it has been made to yield important geometric designs, which are used to ornament our walls and floors.

So likewise was the camera obscura of Baptista Porta, till the progress of chemical knowledge discovered the means of fixing its fleeting shadows.

And then, the magic lantern, which was to be found in every complete liliputian warehouse, was only regarded as a pleasing optical toy, till, in the course of time, its practical value was discovered, and it has now become a useful and instructive instrument in applied science.

Among all the subjects to which science has been applied, it must be universally admitted there is none more important than optics.

It is to one branch alone that I ask your attention, the formation of images by means of lenses, and in this connection I will try and tell you something about the magic lantern.

It will be necessary to make a digression here, and tell you something of the little historical knowledge we have on the subject.

In looking over the old Dutch and Latin books, at times mention is made of the magic lantern or lanthorn. A definition in an old Latin dictionary is a small optical instrument which, by a small gloomy light, shows monsters so hideous that those not in the secret believed them to be performed by magic art.

Another book speaks of a majick lanthorn, which, when used in an obscure place, produces many hideous shapes.

One is soon convinced that the early history of the magic lantern is very uncertain, and many ingenious antiquaries, finding the want of authentic records, have endeavored to supply the deficiency by conjecture founded on casual and obscure allusion to ancient writers, and have invented many vague and unsatisfactory answers, that upon investigation are found to be without foundation.

Magic is derived from "Mag," a surname of Zoroaster, the legislator and prophet of the ancient Bactrians, whose system of religion was the national faith of Persia.*

These priests or "magi," of the old Persian fire-worshipers were a superior class, and by the populace were supposed to be on close terms of intercommunion with disembodied spirits, by whose aid many of their scientific wonders were accomplished. They were in exclusive possession of scientific knowledge, and so celebrated were they in astrology and enchantment, that the name magic was given to all kinds of enchanters, and hence they were called magicians. Some of the different forms which the belief in magic has assumed are known under different names. For example: "Amulet" is an ornamental gem-scroll worn as a remedy or preservative against evils or mischief, as disease or witchcraft, and generally inscribed with mystic forms or characters. "Auguries:" the art or practice of foretelling events by observing the actions of birds, or other phenomena. "Divination:" the act of foretelling future events, or discovering things secret or obscure, by the aid of superior beings, or by other than human means. "Incantation:" the process of using certain formulas of words and ceremonies for the purpose of raising spirits or performing other magical actions. "Witchcraft:" intercourse with evil spirits; power more than natural. "Alchemy:" a science which aimed to transmute base metals into gold, and to find the panacea or elixir of life. "Astrology:" the science of the stars, and fortelling events by their position and aspects.

The above are given as modifications of the idea conveyed by the word "magic."

It is highly probable that the mode of producing images by an apparatus similar to that of the magic lantern was early discovered, and was used by men who claimed occult powers in producing those appearances which may have been deemed supernatural by the ignorant of all ages. Dr. Thomas Young asserts that Friar Roger Bacon invented and used a magic lantern in 1252. This was most probably some arrangement of concave mirrors, which the ancients were familiar with.

In the Latin book "Ars Magna Lucis et Umbræ," published in the middle of the XVII century (1640) by Kircher, a description of a magic lantern is given used by him at the Jesuits' College in Rome. The apparatus was large and imperfect, and the paintings of the roughest style of art.

From ancient authors we may conjecture that the first optical illusion employed was the throwing of spectral images of living persons and other objects upon the smoke of burning incense by means of concave metal mirrors. Spectral

---

* Heeren's Ancient Nations of Asia, Vol. I, p. 378.

images, by reflection of moving objects, were described in the XIV and XVI centuries.

The existence of a camera obscura at the latter date is a fact, for the instrument is described by Giambattista della Porta, the Neapolitan philosopher, who was born in Naples about 1540, in his "Magia Naturalis" in 1558, and the doubt how magic lantern effects could have been produced in the XIV century, when the lantern itself is alleged to have been invented by Athanasius Kircher in the middle of the XVI century, is set at rest by the fact that glass lenses were constructed in Porta's time.

The honor of the discovery of the camera obscura is ascribed at a much earlier date to Leonardo da Vinci, who was born in 1452. He was the miracle of that age—a great mathematician, architect, chemist, engineer, musician, poet and painter. He wrote a book on Light and Shadows, in which he describes the camera obscura.

Roger Bacon, about 1260, speaks of glass lenses so well made as to give good telescopic and microscopic effects.

To seek for more sober or better authenticated information among historians, so far as it has been my fortune to discover, would, nevertheless, be a hopeless and unavailing pursuit; little more is to be gathered than an occasional reference, or rather a compilation of statements already made.

Luminous projections have for past years been a convenient means of illustrating lectures. This system of teaching has been brought to a high state of perfection and is now used in all our large colleges to illustrate every scientific subject. The truth is held "that what is seen is much better known and remembered than that which is only heard." Advantage has been taken of this, and it is now an established fact that information which can be imparted by the eye and ear at the same time, and conveyed to the brain, will remain more firmly fixed than a mere statement of facts. The truth is, that many exhibitions at the present day depend more upon the magic lantern projections than upon the lectures, and without its valuable aid would lose all interest and fail to convey a proper impression. It is the eye and sense of impression that are excited, and the hearing in most cases is an after thought.

Some lecturers appear as very accomplished travelers when, in reality, all their information is taken from well written guide-books. This wonderful impetus has been due to two causes. First, and most important, is the achievement of photography in producing, expeditiously, positives upon glass, which has indefinitely increased its application. Second, is the better mechanical and optical arrangement of the lantern, which have carried it to a high degree of perfection, together with a practical source of artificial illumination making it possible to project pictures fifty feet in diameter. And it has been so simplified that it comes within the reach of all, and can be used in parlor or hall, and becomes a valuable auxiliary to the teacher or public lecturer.

The fact of the great value of this method of instruction is so well recognized, that New York State alone has appropriated the liberal amount of $18,000 annually for this purpose. This amount is distributed among the eight Normal Colleges of the State.

CHAPTER II.

THE CONSTRUCTION OF THE LANTERN.

We will now consider the construction of the magic lantern. The instrument is very simple; it consists essentially of three principal parts—the source of light; the condensers; and a system of magnifying lenses.

The sources of light that have been used are candles, vegetable and animal oils, petroleum, the oxy-calcium, oxy-hydrogen, magnesium, and electric lights.

In the cheaper forms of lanterns used as toys, candles or oils can be the source of light. The better forms of lanterns are so arranged that refined petroleum (kerosene) can be burnt in one, two, or even five wicks. The one-wick lamp fails to produce satisfactory results, but the dual wicks give a light of good power, and of a color approaching whiteness. The disadvantage of the two-wicks is, that a dark shadow is produced upon the screen, from the fact that the position of the wicks is such that they are not in the axis of the condenser. This objectionable feature has been entirely overcome by the use of a third wick, and is known as the "Triplexicon." The center wick falling in the optic axis entirely removes the dark shadow, and the light is much whiter and produces the best possible effects obtainable by means of an oil lamp.

The advantages of this method of illumination, while it is not so intense as some of the other sources mentioned above, is that it is much cheaper, and requires little, if any, skill to operate it.

When Dr. Hare, of the University of Pennsylvania, invented a blowpipe in which he could burn together the gases oxygen and hydrogen, he obtained a hitherto unknown heat. Lieutenant Drummond, an English army officer, took advantage of this intense source of heat to make a piece of the refractory substance quick-lime white hot, and thus obtained the well known Drummond or oxy-hydrogen light. This was first used as a source of light for engineering operations in the English army. Afterwards it soon found application in and has now become the best and most practical source of light for the lantern. The oxy-calcium is a slight modification of this, substituting coal gas under ordinary house pressure, or alchohol, for the hydrogen gas. This produces a light much inferior to the above, yet far better than that produced by any oil light.

Magnesium in wire or ribbon has been used to some extent, but only for short intervals of time. It produces a very white and intense light, but the mechanical difficulties in the construction of a suitable lamp to supply the ribbon with a uniform motion, added to the objectionable feature that white fumes of magnesium oxide are produced, has excluded it from general use as a source of light.

In the matter of the electric arc-light few improvements have been made to fit it for use in the lantern. The difficulties are two: first, its irregularity or flickering propensities; and second, the want of a proper mechanical appliance to keep the light in the focus of the condenser. Attempts have been made to use the incandescent electric light, but owing to the fact that the intensity of the light is low, and the globe inclosing the carbon filament acts as a lens and produces at times a shadow on the screen, these attempts have met with little success.

These difficulties may possibly be overcome. And this light, if it can be produced with a battery, has many advantages, and it is hoped that those experimenting in this field may meet with success.

Before we leave the question of sources of illumination, it will be well to discuss the application of sunlight to the lantern.

With a window facing the south, and a properly arranged heliostat, this is one of the simplest methods of illumination, for by this means we have always parallel rays, and a simple single condenser is all that is essential for use. Sunlight can of course be used with the ordinary forms of condensers, but these combinations are not necessary.

The heliostat in its simplest form consists of a mirror so arranged that the sunlight will always fall upon the condensers. To insure this condition, two motions of the mirror are necessary, one of which is in a plane parallel to the face of the condenser, while the other is in a plane at right angles to the first. In some of these the motion is imparted by clockwork.

Among the objections to the use of the sun as a source of illumination, is the uncertainty of sunlight and the fact that its use is restricted to daytime.

Having discussed the sources of light available, the next thing to consider is the lantern proper.

The condensers have for their function the collection of as much light as possible from the source employed and its transmission through the picture. To accomplish this, the condensers should subtend as large an angle as possible at the source of light; that is, they should be large and their distance from the light (that is the focal length) should be short. Single lenses of large diameter are generally of long focus, and a good condenser should have considerable diameter. To reduce the focal length, two or more lenses must be used to produce a good, convergent bundle of rays.

The condensers have been very much improved of late years, and the better class of lanterns are now provided with such combinations of lenses that you can produce convergent or parallel rays, making it possible to polarize the light and use the vertical attachment when needed for experiments of that character, of which mention will be made further on.

The condensers may be divided into four classes, and are called Cresson, Morton, common and French, the two first taking their names from the inventors. Dr. Charles Cresson, of Philadelphia, constructed an excellent combination, consisting of three lenses. The first is a plano-convex 4 inches in diameter, the second a meniscus, and the third a bi-convex. The two last are 4½ inches in diameter. The error of this combination is very small; the marginal and axial rays coincide within one-tenth of an inch; and the cone of light is about 65°. The only objection to the general introduction of this combination is its cost of construction. (Fig. 1.) To complete this condenser, a lens, 12 or 15-inch focus, was placed in front for a certain class of experiments.

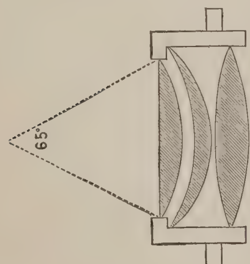


Fig. 1.

Professor Henry Morton, of the Stevens Institute, who has done so much to-

words perfecting the lantern, constructed a combination of lenses in which all are plano-convex, reducing the cost of the Cresson combination more than one-half, and at the same time maintaining its efficiency. The Morton combination consists of three lenses, the first of which is 18-inch focus, $4\frac{1}{2}$ inches in diameter, the second 14-inch focus, and the third 16-inch focus. The last two are 5 inches in diameter. The first two lenses have their plane surface turned towards the light, the third its plane side from the light. The cone of light is about 45°, and the back focus about 3 inches. The third or outside lens is so mounted that it can at any time be removed in case parallel rays are required, which is necessary for the vertical attachment or polarized light, allowing a reflecting surface to be placed between the condensers and collector. (Fig. 2.) It is less perfect than the Cresson in spherical aberration, but with the use of the lime light, in which the surface is large, it works well enough for all practical purposes, and is now used in most scientific lanterns.

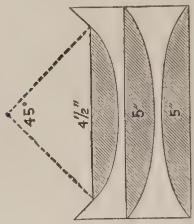


Fig. 2.

The ordinary form of condenser consists of two plano-convex lenses of rather short focus, and are so mounted that their convex sides almost touch. The focus of the combination is about 3 or $3\frac{1}{2}$ inches, and is the usual form used in lanterns for the projection of pictures only. (Fig. 3.) They are less expensive than the triplet form; are more compact; and fully meet the requirements demanded of them. They range in diameter from $2\frac{1}{2}$ to about 6 inches, the usual size being $4\frac{1}{2}$ to 5 inches.

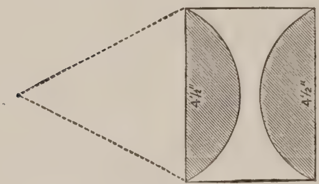


Fig. 3.

The French condenser consists of two lenses, a plano-convex and a double convex, the surface of which is not of the same radii, as the accompanying cut (Fig. 4) will show. These are used in many of the imported lanterns and work very well. The only care in using them is the careful centering of the light to prevent a dark field or fringes.

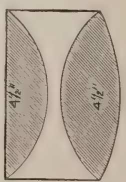


Fig. 4.

Those who attended Professor Tyndall's lectures delivered in 1871, must have noticed that his production of parallel beams of light, such as are necessary for the projection of Lassajous' figures with tuning-forks, and other physical experiments requiring a small pencil of light, was most perfect. Yet his picture projections were imperfect, from the fact that the condensers were not arranged to produce the best effects for picture projections. In fact they were the uncorrected lenses made by Duboscq, and when a small pencil of light was required, a metal plate was placed against the back condenser with an opening or diaphragm of small size that reduced the error of the lens to that of one of an equal size to the opening; whereas, had he used a better combination of condenser, this would not have been necessary.

The next part of the lantern that we must notice is the objective, or means of producing a magnified image of the picture or object. Its first function is to

produce a magnified inverted image of the picture or object. In the cheap form of lantern this is simply a small double convex lens of short focus. A good objective is the portrait combination which is corrected for spherical and chromatic aberration, an essential in the objective, although not so necessary in the condensers. Its second function is to bring the marginal rays of each pencil of light from the condenser to coincide with the axial rays. Therefore, the more concentrated the cone of light, the nearer in each pencil will be the marginal rays to the axial rays, and the more perfectly will the image be projected.

It is only recently that opticians have devoted any attention to the construction of lenses specially designed for lantern objectives, and it is to be hoped that their labors may be crowned with success, for many of the portrait combinations sold with lanterns fail to produce sharp or well-defined pictures. The use of a single uncorrected lens is confined to experiments in spectrum analysis and polarized light, and a few other physical experiments. This uncorrected lens should never be used for projecting pictures.

The ordinary portrait combination consists of four lenses, the back and front, each of two lenses; the front lenses are cemented together and look like one lens; the back lenses are separated by a ring.

In cleaning them always be careful to return them in the proper position—the front lens curved side toward the back—the back lens, that is the thin one, is put in first, then the ring, and last the concave one, with its concave side toward the front.

The size of the image produced by the objective depends upon its focal length and the distance of the lantern from the screen. The greater the distance the larger the picture and less the light, which latter diminishes inversely as the square of the distance. Thus, a picture ten feet in diameter will be twice as well illuminated as one fourteen feet, and a twenty-foot picture will have diminished four times in intensity. For a long distance and a large screen, twenty-five feet or thirty-five feet in diameter, the light can be somewhat increased, yet the limit is soon reached, being determined by size of opening of jet, and the consumption of the gases, after which there is no further gain of intensity. Some prefer to place the lantern at a long distance, and use large and long focus lenses, while others have the lantern near at hand and use short focus objectives; the choice of the two positions depends upon circumstances, location and convenience.

It is convenient at times to determine the distance at which to locate the lantern from the screen that will give the required circle, and the following calculation can be used.

To produce a circle 15 feet diameter with a 6-inch lens and a slide 3 inches :

$$L = \frac{D \times F}{S.}$$

L—Lantern from screen.
F—Focus of objective.
D—Diameter of circle.
L—Size of slide opening.

Or, in other words, multiply the diameter of disk by the focus of lens, and divide by opening in slide.

$$\begin{array}{r} 15 \\ \underline{6} \\ 3\overline{)90} \\ 30 \end{array}$$

30 feet from screen = 15 feet circle.

The focal length of a lens can be determined approximately by holding it near a window with bars, and letting the image fall upon a white surface; then measure the distance at which a sharp outline is produced, which gives you the focus.

The pictures magnified are usually transparent, and the images are formed by the rays which have been transmitted through them. The linear magnifying power is the number of times an object is magnified; the superficial magnifying power relates to the entire surface. This power should always be expressed in linear measurement, as the superficial area is apt to mislead.

CHAPTER III.

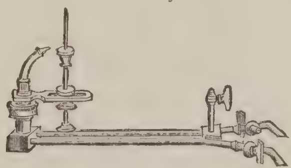
THE SOURCES OF ILLUMINATION.

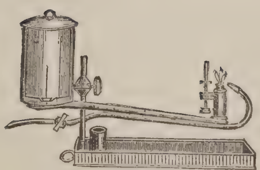
We now come to the consideration of the jet of the oxy-hydrogen light used in connection with lime as a source of illumination in the lantern.

Jets are divided into blow-through, simple and compound. The blow-through include those that burn ordinary illuminating gas or alcohol to supply the hydrogen through which the oxygen is made to pass. These jets are simple in construction and produce fairly good results.

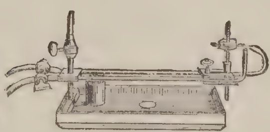
The simple jet is one where the oxygen and hydrogen gases mix at the tip and are not combined until they leave the aperture of the delivery tube. With this jet ordinary illuminating gas can be used direct from the fixtures; it gives a better light than the blow-through, but both of these are more expensive in consumption of gas than the compound jet, which differs in this respect, that the

COMPOUND JET.





ALCOHOL JET.



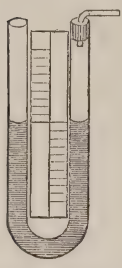
SIMPLE JET.

Fig. 5.

two gases mix in a small chamber, or tube, before they pass through the tip of the jet, yielding the greatest intensity of light with least consumption of gas. This latter is the principle of all the best forms of jets now used in lanterns. With this jet it is essential to have the gases under a pressure of 4 or 5 inches of water, and it is mostly used in connection with cylinders.

At times it is convenient to determine this pressure, and a simple piece of apparatus, which can be easily made, consists of a bent U-shaped glass tube about three-eighths of an inch inside diameter, with branches about eight inches long on each side. A wooden or metal scale is placed between the branches, divided into inches and tenths, in the middle of which is placed a zero point. The tubes are filled with colored water to the zero mark. When the gas is turned on it

depresses one column and raises the other. The sum of the two readings indicates the pressure. (See Fig. 6.)



PRESSURE GAUGE
FIG. 6.

Some of the compound jets are perforated by small openings in the mixing chamber, giving the gases a circular motion, producing a more uniform delivery and are not as liable to produce that annoying hissing or whistling sound which is often heard in the lantern. This noise is due more largely to imperfection in the tip of the jet, which is made either of brass, iron, or, in some cases, tipped with platinum. The openings vary in size and number—some have one, two, or even three holes. Those that have been thus far a success are the jets with single openings, which in all cases should be perfectly round and smooth on the inside, that the gases may pass with little friction, thus preventing hissing or whistling. The size of opening for a jet used for a very intense light is about $\frac{1}{16}$ of an inch, the usual size being about $\frac{1}{20}$ of an inch.

The pressure at which the gases burn at the jet and the amount consumed per hour had never been determined, so far as I am aware, and feeling that this somewhat disputed question might be put at rest, I determined to make these measurements, and the experiments were conducted in the following manner: Two gas meters reading cubic feet per hour by minute observations, one for oxygen, the other for hydrogen; two water-pressure gauges divided into inches and tenths; two wash-bottles to watch the flow of the gas and prevent explosion; and a compound jet with an opening $\frac{1}{16}$ of an inch, comprised the apparatus. The light was started, the pressure noted, and the amount consumed read from the meters by six observations, the average of which is as follows:

Hydrogen consumed per hour	$4\frac{2}{10}$ cubic feet.
Oxygen " " "	$3\frac{6}{10}$ " "
Pressure at the jet was	4 inches water.

The pressure was much less than was anticipated, being equal to about five ounces avoirdupois on the square inch.

One of the essentials to success with the lantern when the lime light is used, is the careful selection of the lime cylinders. The limes used should be hard and compact, and free from fracture; of about three-quarters of an inch in diameter and two or three inches long. They can be purchased in this form, but in preference to buying, many make their own limes by cutting them from any good unslacked lime; they can be easily shaped by using a good coarse flat file. The effect of the great heat upon the lime is to produce a pit or cavity which reduces the intensity of the light, and the flame is liable to be deflected and strike the condenser, producing a fracture; to prevent this it is necessary that the lime should be turned every few minutes. Some holders for the lime are so arranged as to give a rotary motion to the lime by means of clockwork, which is rather a scientific refinement than of practical importance.

After using the limes, and when nearly cold, they should be placed in a well-stoppered bottle, free from moisture, and can be used over and over again, care being taken to examine them for any defects before use. Some limes can only be used once, and it sometimes happens that a lime has to be changed during an

exhibition. It is always well to allow the hydrogen to heat the lime before admitting the oxygen, for a too rapid heating is the cause of fracture, in which case the lime must be rejected.

Oxygen.—For a supply of this gas we depend upon some salt that contains it chemically combined, and one that will yield it at a moderate heat. The only practical compound is potassium chlorate, which, when heated, gives off its oxygen, leaving potassium chloride. When the chlorate is heated alone it melts and the gas is disengaged very rapidly. To prevent this too violent chemical decomposition it is mixed with some gritty material, as sand or powdered glass, or, better still, the oxide of manganese. With this mixture the gas is liberated at a far lower temperature. The oxide of manganese does not yield any oxygen, remaining quite unaltered, and is only added to modify the too rapid chemical action. The materials used must be commercially pure and free from organic matter. The chlorate comes in crystals, which is pure enough; the manganese is a black powder and is called black oxide of manganese. This should be tested by heating on a metal plate or iron spoon, and should it give sparks or flashes it must be rejected. The proportions best adapted for the largest yield ot oxygen at a moderate temperature are chlorate 100 parts, manganese 25 parts, by weight. This mixture is introduced into a retort, made either of Russian iron or copper, which is placed on a support, and heat applied. The delivery tube from the retort should connect with a wash-bottle, from which the gas passes to suitable holders. The practical yield of oxygen from one pound of chlorate is from $4\frac{1}{2}$ to 5 cubic feet, or about 30 to 38 gallons. There is no danger attending the preparation of oxygen if you have pure materials and a large delivery tube from the retort and wash bottle.

This gas is now manufactured on a large scale and has become a commercial product. Gases occupy so large a space, that it is found more practical and convenient to compress them for transportation in metal cylinders holding from 10 to 75 cubic feet. The compression is about 12 volumes, or 25 cubic feet in cylinders of 2 cubic feet capacity, which requires a pressure of 225 pounds on each square inch. The principal cost is in the time and power required to compress the gas in the cylinders. The convenience, however, more than compensates for the trouble of making and storing the gas, and it is now to be obtained in all the large cities.

The delivery cock from the cylinders, which is situated on the top, has a fine-threaded movement, and by carefully moving it from left to right with a key or handle, the gas can be delivered to the jet at a low pressure and in small quantities.

In some institutions, where a permanent position is secured, and it is convenient to store a large quantity at a time to last for a number of lectures or use in the laboratory, they generally make the gas and store it in large gas-holders, which deliver it at an equal pressure to the lantern.

When small quantities of oxygen are required several methods have been employed. The most simple is heating the oxygen mixture in small retorts or long tin tubes, and conveying the gas either to a rubber bag or small gas-holder, and thence to the lantern. The tin tubes can be made of different lengths or sizes, depending upon the amount of gas to be generated; and the holders being small, the gas can be regulated by only heating a small portion of the tube at a

time, of course applying the heat at first to the end of the tube nearest the outlet. By this means you are enabled to generate the gas at the same time that it is consumed. This is said to have been first introduced by Mr. M. Noton, of England, where it is now used, and is reported to give satisfactory results.

In using cylinders it is important to have a pressure gauge indicating to 225 pounds, that you can determine the decrease in pressure after using, and should they indicate only 75 pounds, it is well to have them replenished before using.

Hydrogen.—The so-called hydrogen supplied in cylinders is the ordinary illuminating gas, and for all practical purposes gives as good a light as does pure hydrogen. When required on a small scale, it is generated by decomposing water by means of sulphuric acid and metallic zinc. Special apparatus is required for the preparation of this gas, and can be purchased with full directions from all dealers in lantern material.

This gas is highly combustible, and when mixed with air or oxygen produces a dangerously explosive mixture, and for that reason is not to be recommended when stored in rubber bags, the use of which is fast being superseded by the use of gas compressed in cylinders. In this latter condition it is considered perfectly safe, as the gas is always under pressure sufficient to prevent running back and exploding. In most cities or towns a supply of illuminating gas can now be found, which can be run into the gas bag for use, doing away with the manufacture of hydrogen. When it is found necessary to use hydrogen from a bag, it is always important to introduce between the bag and jet a wash bottle, which precludes a possible ignition and explosion. It is far more safe to use the gas compressed in cylinders or from the gas-pipe direct; for in this way we avoid all possible chances of an explosion.

This gas in cylinders is furnished by the same companies that supply the oxygen, and the cylinder is painted black to distinguish it from the oxygen, which is painted red.

I have enlarged somewhat upon the dangers attending the use of this gas when used from bags, for the reason that those who may wish to experiment with it, and not thoroughly understanding the nature of the gas, and whose experience may be limited in preparing and handling combustible gas, this caution may not be out of place, as exhibitions at times are brought to a sudden termination from an accidental explosion by the flame running back on the unequal pressure, which allows the gases to mix and ignite. It requires considerable skill and experience in handling hydrogen from bags, and whenever possible, use the gas compressed in cylinders. Some attempts have been made to substitute some of the more volatile bodies, such as benzole, gasoline, ether, etc., to produce the hydrogen by passing air through them, or to vaporize them direct; and were it not for the combustible and explosive nature of these bodies, they would no doubt meet with more approval.

CHAPTER IV.

SIZE OF LANTERN.—CARRIERS.—DISSOLVERS.

Size of Lantern.—The size of the body is only a matter of fancy. Some manufacturers still make them large and imposing to attract attention, while others resort to nickel-plating and much highly finished brass-work. The aim at present is to reduce the size and weight to suit circumstances; for a small body, if well ventilated, is all that is necessary. The only function of the body is to prevent the light being diffused in the room. Some of the last forms of lantern are constructed by mounting the condensers and objective upon a base board; and attached to the jet is a metal cone with a small opening for the light to enter the condensers, the lime being covered with a small hood, thus doing away with a body entirely.

Some of the older lanterns measured 18 inches high, 14 inches wide and 20 inches deep, for the reason that the condensers were large and the focus sometimes as much as 9 to 15 inches, with a chimney having two angle elbows and 16 inches high.

There are many designs of lanterns to be found in the market, all of which no doubt are possessed of some merit. If the lantern is designed for transportation, it should be as compact and light as possible. If to be located in a lecture-room or hall the weight is an advantage, as it makes it more rigid and will better carry the vertical attachment, gas microscope, or polarizing elbow, and such accessory apparatus as is necessary. If designed for use with the electric light, it is usual to place the body upon four pillars or uprights, to admit the introduction of some form of regulator to be used with the arc light. It is of great importance to have the jet so arranged that the operator can make the adjustments from the outside, and thus avoid the light being diffused from opening the door of the lantern, which has a tendency also to reduce the light upon the screen. In fact some exhibitors take the precaution to inclose the operator and lantern in a dark room made of cloth, making it impossible for any light to gain entrance to the audience.

It will be impossible to give dimensions that would be of any value, as each maker sets forth certain claims for this or that size lantern, and the matter is left with the reader to buy, make or use any size body that he may desire.

The materials used are mostly metal; in some cases wood is used for its greater beauty of finish, but this requires to be lined with metal to protect it from the intense heat. By consulting the catalogues of dealers, the reader will in this way get an idea of the many designs and the magnitude of the industry; for it has now become an important factor in science, education and amusement.

Holders or Carriers, the design of which is to bring the picture in the center of the condenser. This would not be a difficult matter if the pictures were of a uniform size, and it is to be regretted that producers have not agreed upon a definite standard size. The result is that we have several arbitrary sizes. The only one that approaches to a general adoption, and is known as the trade size, is

$3\frac{1}{4} \times 4$. The others are $3\frac{1}{4} \times 4\frac{1}{4}$, $3\frac{1}{4}$ square, $3\frac{3}{8} \times 3\frac{1}{4}$, $3\frac{7}{8} \times 3\frac{1}{4}$, and $4\frac{1}{4} \times 5\frac{1}{2}$, and some are to be found $6\frac{1}{2} \times 8\frac{1}{2}$. Those mounted in wooden carriers measure 7 inches long, 4 inches wide, $\frac{3}{8}$-inch thick, with an opening of 3 inches. The ordinary carriers, made of metal, answer for the regular sizes. For the others an adjustable holder is made on the principle of the parallel ruler, which by a lever can be enlarged or reduced to take all sizes used for the lantern.

The holder—placed with the opening in the center of the condenser—should be long enough to hold several pictures at a time, and have notches in it to indicate the central position of the picture.

Dissolvers.—Several devices can be used, the aim of which in all cases is to produce a gradual diminution of the light until the picture disappears, and by a gradual increase of light reappears.

Dissolving effects can be produced by a single lantern, and they are thus spoken of as double or single dissolvers.

When produced by a single lantern, the gradation of the light is produced by means of an elongated conical opening cut in a wood or metal strip, which is placed in front of the objective and is made to move across the aperture of the lens, which will so modify the light as to produce fairly good results. (See Fig. 7.) The same opening can be used on two lanterns if necessary, and acts well when the source of light is refined petroleum.

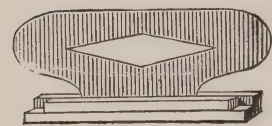


FIG. 7.

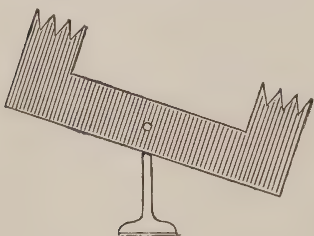


FIG. 8.

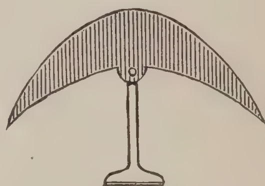


FIG. 9.

Another form of dissolver is a serrated plate, which is likewise used in front of the objective. (See Fig. 8.) Another method consists in using a crescent-shaped opening, which is so arranged that as the picture is moving in place the aperture will be closed, and as the picture takes its central position in front of the condensers, the crescent-shaped opening will so expand as to allow the light to pass and illuminate the screen. (See Fig. 9.) These are called mechanical dissolvers.

They fail to give results as pleasing as those to be described, and which are produced by regulating the flow of the gases by means of a "dissolving key." These keys are divided into high and low-pressure dissolvers. The low-pressure keys are more simple in construction, but require that the adjustment of the gas be made either at the bags or cylinders, and need constant attention. The construction of the key is such that a certain amount of hydrogen shall remain burning in one lantern, while the full supply of both oxygen and hydrogen shall be delivered to the lantern projecting the picture, and then reversing

the operation. This is effected by using a slightly tapering plug, in the side of which grooves are carefully cut, so that by moving it around its center the flow of the gas can be directed wholly or in part to either lantern.

Many devices have from time to time appeared, all of which involve the above principle in construction. It was found that the above worked well when the gases were not under very great pressure, as that produced by pressure boards on gas bags. Since the introduction of compressed gases in cylinders, it required a key that would be able to receive the full pressure of 225 pounds to the square inch; hence the term "high-pressure key." The principle of construction is the same as in the low-pressure key, yet it requires more mechanical skill, as the channels through which the gas enters at a high pressure deliver it to the jet at a low pressure; for this purpose additional grooves have to be cut in the tapering plug. The plug must fit tight enough to prevent the gas leaking and yet admit of being easily moved in its socket without lubrication. The first successful key was made by Mr. A. G. Buzby from gun-metal and sold by the publishers of the PHOTOGRAPHIC BULLETIN. Several excellent keys are now to be had which have been tried by the author, and work satisfactorily under all tests. Many of them have the objectionable feature of blowing out the hydrogen, and snapping or failing to deliver the proper supply of oxygen, which reduces the intensity of the light. Properly constructed keys should be free from these defects, and when used they have the great advantage that the gases can be turned on at the cylinders under full pressure, and all the regulating done at the key by the operator. It requires considerable practice, even with a perfect key, to produce fine results, as a good key in the hands of inexperienced persons might result in failure.

These high-pressure keys are constructed with a double central plug, and four small ones, the latter receiving the direct high pressure from the cylinders and delivering to the central plug at low pressure; while others depend upon one long central plug which enters two chambers, thus dividing the key into two separate parts. With either of these keys the gas can be so regulated that what difference there may be in the size of the opening in the jet, the light can be made of equal intensity in each lantern, which is one of the great difficulties to overcome without constant attention on the part of the operator when using a single central plug dissolver. In keys constructed on this principle the high pressure from the cylinders comes in contact with four plugs or stopcocks, and in turn is delivered to the central plug at low pressure, from which it is delivered to the jets; they are, therefore, high and low-pressure keys in one.

It would hardly interest the reader to go into the details of construction of each named lantern, as what is said about one applies to all in general construction, and they only differ in size, weight, and material. In all cases it is of the utmost importance that the fundamental points mentioned—the light, condensers, and objectives—should be selected of good material and workmanship.

The condenser lenses should be free from striæ, air-bubbles, scratches, and of a uniform light bluish color, and be so mounted in brass that they can be easily unscrewed and cleaned. The objectives best suited for projection are those that give a flat field free from central flare, and should give a well defined image, as the chief merit or excellence of a representative image consists in its distinctness or clearness. For what is more painful to the eye than a picture

half-effaced or blurred, the result of an imperfectly constructed objective; or, at times, the fault of the operator in not properly focusing.

The jet should come in for some little consideration, as its faults are made manifest by a whistling, buzzing, hissing, disagreeable, and, to say the least, an annoying sound. Such a jet should at once be discarded, as these faults are in construction and can be overcome by making the opening smooth and not too large. The best constructed jet can be made to fall into the above bad habits if too great a pressure is forced upon it.

CHAPTER V.

VARIOUS FORMS OF LANTERNS.

Having briefly discussed the optical and mechanical portions of the lantern, it will be well at this point to mention a few of the many curious names given to lanterns, and then consider some of the details of construction of the more important ones.

I will endeavor to be as concise as possible in describing the parts, so that the reader may have a general knowledge of the construction of the different kinds.

Names of Lanterns.

Magic Lantern.
Stereopticon (to see solid) or Dissolving Lantern.
Phantasmagoria. Ghost-like.
Sciopticon. Shadow to see.
Triplexicon. Three wicks.
Dioptric. Refraction.
Binoptric. Prismatic lantern.
Trinoptric. Three lanterns in one.
Biunials or Doublets. One over the other.
Triplet or Triunial. Three-stories high.
Pamphengos. Bright light.
Aphengescope. Without light.
Polyopticon. Many to see.
Megascope. Great to view.
Euphaneron. Abundantly visible. Has four wicks.
Pantaphane. Five-light. Has five wicks.
Solagraph Cyclexicon. To write comprehensive.
Photogenic. Light-producing.

The first forms of magic lanterns were large and cumbersome; and even as late as 1838 little change had been made in the general construction from those used at an early date.

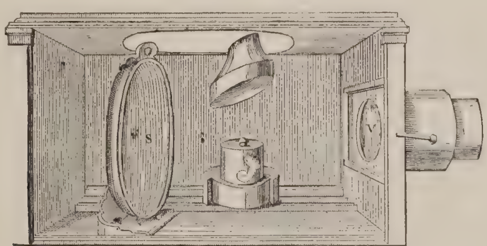


Fig. *A*.

The illustrations (Figs. *A* and *B*) taken from "Smith's Optics," published in 1838, gives the reader some idea of the condition of the magic lantern at this

date. The box was 14 inches high, 14 inches wide, and the mirror a concave speculum 8 inches in diameter. The lamp was made up of four little wicks,

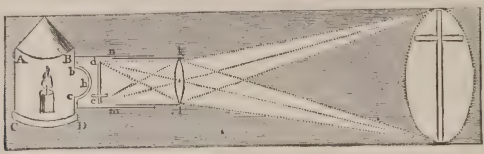


Fig. *B*.

which, by touching each other, made one flame 2 inches wide. This apparatus was called the Lanterna Megalographica.

Stereopticon; or, Dissolving Lantern.—This involves the use of two lanterns, which are so arranged that the illuminated circles shall exactly register (coincide) on the screen. It was supposed that a stereoscopic effect could in this way be produced, and was at first held a great secret, until the fact was made known that only one picture was used at a time, making it impossible to yield such an effect. Hence the name stereopticon is a misnomer; it should be called a dissolving lantern.

This method of projection is now used at all first-class exhibitions, and, when properly manipulated, produces a very pleasing and striking effect.

Phantasmagoria effects, first credited to Cellini, are produced by moving the lantern gradually backward and forward behind a muslin screen, thus diminishing or enlarging the object at will. The lantern is usually carried in one arm, focusing during the motion with the other hand, thus rendering the picture upon the screen always distinct.

The construction of the lantern for this purpose does not differ from the ordinary one, as any lantern can be used. If gas is used, care should be taken to see that the rubber tubes conveying the gases are not stepped upon, and are long enough to reach to back of stage or room.

The lantern is sometimes placed upon wheels and the focusing is accomplished by rods or levers connected with the thumb-screw of the objective, which slides in the tube. I am of the opinion that the required effects can be as efficaciously produced by the hand adjustment, doing away with this needless and expensive mechanism, which at times fails to operate.

With a careful selection of pictures—the best suited are silhouettes and comic slides—this can be made to contribute largely to an evening's entertainment.

The Sciopticon was among the first in which a double-wick lamp was used, a new departure in the method of illumination and a great improvement over the single flat wick or argand burner. It has a small semicircular body which adds to its lightness and portability. The great objection to the use of two wicks is the dark shadow crossing the illuminated disk in a vertical direction. For views it is hardly perceptible, but for outline pictures it is visible at all times. To overcome this difficulty the wicks are sometimes placed diagonal to the axis of the condensers. This has a tendency to reduce the shadow and to some extent the intensity of the illumination. A difficulty is that unless the air supply is carefully regulated the flame is more likely to fork.

Triplexicon.—This lantern is furnished with a lamp having three large wicks, which removes the dark central vertical line seen with those having two wicks. The three wicks give a bright, flat disk of light, evenly distributed over the entire

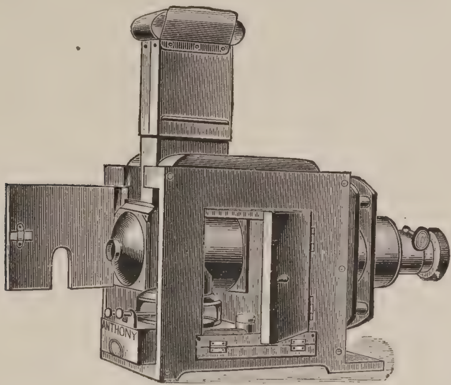


FIG. 10.

circle, which has secured for it an unexceptionable reputation. Its optical construction is of good quality, and it is in all probability the best oil light lantern used at present. Its novel method of air supply and ventilation reduces the heat to a minimum. (See Fig. 10.)

Various other forms of oil lanterns are manufactured, some with four and even five wicks, but my experience has been that they add little to the intensity of the light, but largely to the heat, which is a serious drawback to their general introduction. They are included in the pamphengos, aphengescope, euphaneron, pantaphane, solagraph-cyclexicon and photogenic. All of these depend mainly upon an oil lamp with from two to five wicks as a source of illumination. In some cases they are so arranged that a gas jet may be substituted for the lamp, which is often found a great convenience.

For a circle of six or eight feet the oil lamp will give good results, and is well adapted for home or class projections. If intended to exhibit in a hall or large lecture-room I would advise the use of the oxy-calcium jet, which will illuminate a circle of twelve feet. If any larger circle be required, then introduce the oxy-hydrogen jet.

We now come to a curious and somewhat novel style of lantern, which at the time of its invention, in 1847, seemed to promise well, for it involved a new principle for lantern projection. It made use of a well-known principle in physics—the total reflection prism, which was first applied by Sir Isaac Newton, instead of a plane mirror for reflecting telescopes. The principle is, that if we use a glass prism having an angle of 45°, or a right angle prism, rays falling on the face will be reflected as if it were a plane metallic mirror; for whatever be the refraction which they suffer at the entrance face, they will suffer an equal and opposite one at the emergent face. The value of such a prism is that the rays of incidence fall at an angle greater than that at which total reflection commences,

and, therefore, *they will all suffer total reflection.* A portion of the light, however, is lost by reflection at the two surfaces, and a small portion by absorption of the glass.

The application of this to the lantern was first made use of by the Rev. St. Vincent Beechey, and he called it the *Prismatic Dioptric Dissolving Apparatus.* The prisms were mounted in front of the objective, and could be moved so as to reflect the image to any particular position. The advantage claimed by the inventor was that it possessed less compass than the ordinary lantern, and yet had the power of two combined in one. With the use of one lamp, which was upon the ordinary fountain-lamp principle, with a circular wick, a small lime ball being suspended in the apex of the flame, upon which impinged a supply of oxygen gas, an intense light was produced, supposed to possess sufficient illuminating power to cover a twenty-foot circle. It was simple to manage, and the consumption of gas was small. Had these anticipations been realized, it would have been a great success, but, unfortunately, the lamp was a failure, together with the large amount of light lost by absorption and reflection from the outer surface of the prisms, while the cost of the apparatus was not less than for two lanterns; for these reasons the apparatus was not a success, and was soon lost sight of.

The Trinoptric Lantern differs but little from the original idea of the former, having the addition of a tube in the center, carrying an objective without a prism, directly in front of the lantern, which combines the power of three lanterns in one with the use of a single lamp, the same in principle as used in the dioptric, with the exception that the lime ball is omitted. By means of this lantern the three disks from the prisms may be thrown either altogether on one circle or united at various distances on the screen, to form one panoramic picture, thus producing all the effects obtained by the use of three lanterns.

Prismatic Binoptric Lantern.—This is essentially the same as the other two, the only addition being a third prism on the central objective. To all three a system of mechanical dissolvers was attached, for the aim of these lanterns was to produce dissolving effects by means of one light and the total reflection prisms.

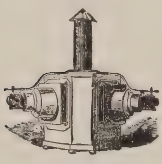


FIG. 11.
DIOPTRIC LANTERN.

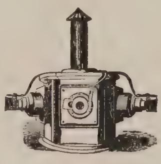


FIG. 12.
TRINOPTRIC LANTERN.

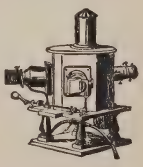


FIG. 13.
PRISMATIC BINOPTRIC LANTERN.

In looking over some old catalogues, which were published over forty years ago, I was fortunate enough to find some illustrations of these curious lanterns, which are reproduced, and will give the reader some idea of their construction, as well as the attention that was given to the lantern at this date, 1847. Their only value at present is historical. (See Figs. 11, 12 and 13.)

Keevil's Lantern.—This is only a modification of the others, with the exception that the jet is arranged on a pivot, and by rotating it through about a quarter

of a circle the light is brought in the axis of the condensers alternately, and at the same time the mechanical dissolver opens and closes the objectives. (See Fig. 14.)

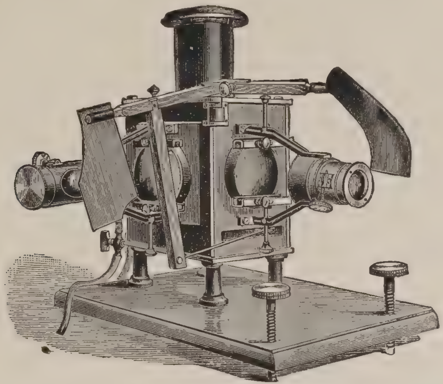


FIG. 14. KEEVIL'S LANTERN.

Biunials.—Lanterns mounted one above the other are designated as *biunial.* Many designs of these are to be found in foreign catalogues, principally of Lon-

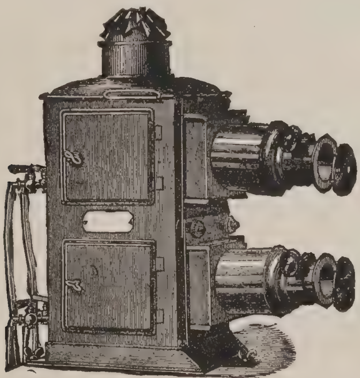


FIG. 15.

don make. (See Fig. 15.) A few are in use in this country, some of which are so mounted as to be removed at will and used as a single lantern.

The great point in their construction is to insure perfect ventilation, which is produced by means of a side flue from the lower lantern, the upper one being ventilated in the usual way from the top.

Triunial; or, Triple Lantern.—This form of lantern seems to be in favor in England, and is used to some extent in this country. (See Fig. 16.) The advantage of a third lantern is for producing some pleasing effects, among which are

the change from day to night; summer to winter; formation of rainbows; lightning; storming of forts; and many other things, as the introduction of statuary and tinting, and movable or panoramic pictures.

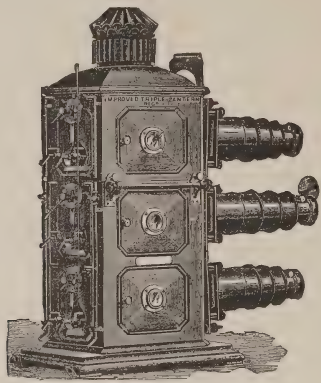


Fig. 16.

At the Royal Polytechnic Institution as many as six lanterns were used for the projection of effect slides.

A form of lantern designed more especially for experimental purposes is constructed by Duboscq, of Paris. It differs a little from the one designed by

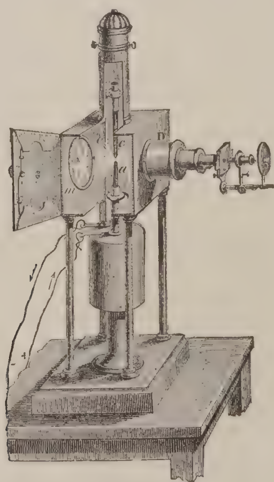


Fig. 17.

Professor Morton in having a long slot in the chimney to admit the electric light regulator, and is supplied with a series of condensers of different focal lengths.

Fig. 17 represents the arrangement as devised by Dubocsq. The microscope

can be replaced by the vertical, spectrum, and polarizing apparatus, and is well adapted for exhibiting optical phenomena to a large audience.

Polyopticon; or, Wonder Camera.—The object of this apparatus is the projection of opaque objects upon the screen. Heretofore we have spoken of transparent objects shown by transmitted light; now we have to deal with opaque objects, many of which are highly interesting—as minerals, medals, casts,

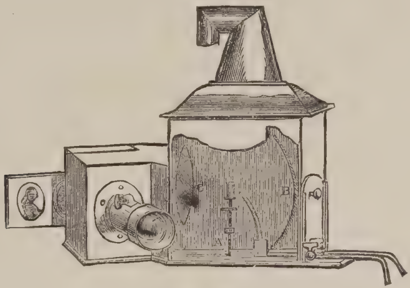


FIG. 18.

flowers, photographs on paper, engravings, the delicate mechanism of a watch in motion, and many other things, can in this way be projected with fairly good results. It meets with general favor, because it reflects objects in their natural colors.

It is simple in construction, and in the toy form is merely a light with a reflector, a frame to hold the object, and a single plano-convex lens to enlarge it. In the more perfect apparatus it is so arranged that it can be attached to the ordinary lantern by removing the objective so that the light from the condenser may impinge upon the object (which must be highly illuminated), then, through the objective (which is placed on the side of the angular box, joined to the condenser), and then projected upon the screen. When illuminated by the oxy-hydrogen light, very satisfactory results may be obtained. (See Fig. 18.)

Besides being used as an amusing toy, it has found application to some extent by artists to enlarge with, as a photograph may be used direct.

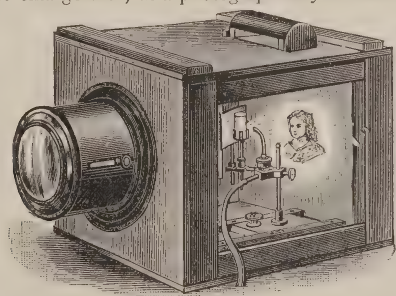


FIG. 19. MEGASCOPE.

The cheap toy instruments are not to be relied upon for any satisfactory effects; the source of illumination required being stronger than oil will give.

Megascope.—This apparatus is a more refined wonder camera, and finds

certain applications for the projection of opaque objects. We must not try to substitute it for the lantern, or we shall be disappointed, for it is of necessity vastly inferior to that instrument in sharpness of definition and flatness of field, while in amount of illumination it is enormously behind. It is only used for a few experiments which cannot be shown otherwise, and if constructed cheaply will be found of much interest, and at times a source of useful service.

To produce the best effects a large lens of long focus, with two oxy-hydrogen lights, and a large box, well ventilated, must be used. This apparatus became an important factor in the Continental Bank case, which was tried in 1877, as by its means a forged and original check was enlarged and projected on a ground glass screen visible to the entire jury.

Photography a Detective Agent.

In 1877, on the trial of the suit brought by Austin, Black & Co., against the Continental Bank to recover some $60,000 on a check upon the bank, the certification to which by A. H. Timpson, the paying teller, was alleged to be a forgery, some interesting photographic experiments were made in the presence of the jury, with a view to determine the fact of the certification in question, and Judge Van Brunt, who held the Supreme Court Circuit. After being on trial for nearly three weeks, the defense closed their case by offering the testimony of Professor Chandler, of Columbia College; Professor Laudy, of the School of Mines; and Professor Morton, of the Stevens Institute. These gentlemen, from photographs taken of the check in dispute and other checks, the genuineness of whose certification was undisputed, indicated what they claimed to be differences in the writing. In order to give ocular demonstration to the jury, a megascope, using two oxy-hydrogen jets, was made use of, the room being properly darkened for this purpose. It was quite a novel exhibition in a court room, as well as a beautiful illustration of the efficacy of scientific knowledge in legal investigation. Upon a large ground glass were pictured mammoth copies of the check in dispute and other checks, and then still more magnified portions of the same checks, thus enabling the jurors with their own eyes to trace out line by line and curve by curve all the angularities and sinuosities of the photographic checks thus presented to view.

CHAPTER VI.

SCREENS—SLIDES—MANAGEMENT OF LANTERN.

HAVING briefly discussed the more important forms of lanterns, it will be well at this point to devote some further time to its applications, and the first in importance is its use for the projection of pictures, or slides as they are called. Before speaking of them, a few words about the surface upon which they are projected may not be out of place.

Screens.—Nothing is better than a good white-finished wall; in the absence of which thick muslin, either painted or kalsomined, that can be attached to a spring roller, is a very convenient method for a hall or lecture-room. If intended for transportation, the paint and kalsomine must be omitted, and muslin used alone; this is fastened to a strong frame, either by tacks or tapes.

Transparent screens are not nearly so well adapted for use as an opaque white surface, as the loss of light by absorption is very great, and the circle must of necessity be small.

When illuminated from behind, and if muslin is used, the screen must be wet to make it translucent and to stretch it. It is better to first attach it to the screen frame and then spray it with water a few hours before use; this makes it more luminous on the side towards the audience.

Fine tracing-cloth can be used; or, better still, a large piece of fine ground glass. For class-room experiments, when the apparatus is hidden from view, it is thought by some that the interest in the experiments is lost when the apparatus is unseen, and it is recommended that the method of projection be described as well as the experiments. For, as Tyndall has said: "Experiments have two great uses—a use in discovery and also in tuition—first comes the discoverer and then the teacher, whose function it is to exalt and modify the experiments so as to render them fit for public presentation, as they are a language addressed to the eye as spoken words are to the ear."

Slides.—The pictures used in the lantern may be divided into paintings direct upon glass, colored photographic positives, silver positives, Woodburytypes, mechanical slides, which include the comic slipping, lever and panoramic slides, silhouettes, and drawings upon ground glass or gelatine with pen or pencil.

The pictures first used with the lantern were all hand-painted, and many were really works of art. They were on glass measuring in some cases six and eight inches square, and as the paintings were to be greatly magnified, the work was confined to a few artists who were familiar with miniature painting, which made these pictures expensive. Many, however, were executed by less skillful hands, and soon found their way into the market.

When the lime light was first suggested, it was objected to on the grounds that the great heat and light would destroy the paintings. They are still colored by hand, as all attempts at mechanical production have thus far failed. The better class of colored slides are mostly reproductions by means of photography

from engravings and paintings, and are beautifully executed by skillful artists with transparent colors, the whole being sealed in balsam and mounted in wooden frames with a round opening.

When the color has been judiciously applied, it adds greatly to the general effect, as the eye is educated to view natural objects in color, and thus they harmonize better with our ideas of nature.

Some of the French colored slides, in which the artist persistently introduces a full moon—and that often in the wrong position—shows to what abuses coloring may be carried. Many times a handsome photographic slide is ruined by the introduction of a gaudy, unnatural cloud and moon effect, and one is compelled to use these miserable daubs, as some of the views of buildings or landscapes cannot be secured without this coloring. Many, however, as the comic slipping and lever slides, are painted direct upon the glass, and it is astonishing to what a degree of perfection this branch has been carried, when we consider the low price at which they are furnished. The slides furnished with the cheap toy lanterns are mostly painted in Nuremberg, Germany, the great center of the toy industries. This place alone produces £800,000 yearly of fancy goods in metal, wood and ornamental colored toys. Some of the cheap French slides are transfers from lithographs upon glass, after which a daub of color is dropped on here and there, without any regard to exact location or effect.

With regard to the coloring of slides, either direct upon the glass or photographic transparencies, it resolves itself into one of patient practice, with a knowledge of the use of palette and brush, and any amount of information conveyed in writing would be useless.

It would also convey us too far away from our present purpose were we to describe the methods, implements and materials used in coloring slides.

The majority of lantern pictures produced for the trade are collodion positives by the wet process. The French still hold to the albumen process, which slides are known by the beautiful warm brown tone, and are called Levy pictures. While the dry gelatino-albumen pictures are slowly being introduced, as yet they have not met with general approval in the trade.

In justice to those who were first instrumental in introducing lantern positives, some little historical account must be given; and the answer to who introduced photographic transparencies for the lantern cannot be better given than by an extract from the London *Art Journal*, which was published in ANTHONY'S BULLETIN some time ago.

Who Invented the Magic Lantern Pictures?

Answer:

BY ROBERT HUNT.

Our attention has, however, been especially excited by some specimens from Philadelphia, to which the inventors have given the names of hyalotypes.

We are not made acquainted with the details of the process, but it appears evident that it is some modification of those processes on glass which we have already published—gelatine or albumen being made the surface on which the sensitive coating is spread. In the original French photographs on glass, the

negatives only were received on that substance, the positive copies being received on paper; this is also the case with the very charming results obtained by Ross and Thompson, of Edinburgh. In the hyalotype, both the positive and negative impressions are obtained on glass, and the result is as near an approach to perfection as we can imagine. The hyalotype is the invention of Messrs. W. & F. Langenheim, of Philadelphia—the proprietors of Mr. Fox Talbot's American patent. These gentlemen state of their process that "The distinguishing feature consists in the material on which the impressions are taken. We have substituted plate-glass for paper in the negative, and also in the positive, altering the process to suit the new material. The best paper is always a fibrous substance, and the texture of the negative paper is always imprinted on the positive picture, and very few Talbotypes were fit to be shown, except after touching them up by hand. In portraits particularly, this process is apt to destroy the likeness."

The most interesting application of this discovery is the construction of *magic-lantern slides, taken from nature by the camera obscura, without the aid of the pencil or brush.*

Already these photographic artists have published one hundred and twenty-six views around Philadelphia, Washington, and New York, including the Penitentiary of Pennsylvania, Mount Vernon, where the remains of Washington repose, the Smithsonian Institute, the Croton Aqueduct and the Capitol at Washington. Portraits of General Taylor, Henry Clay, Van Buren, Audubon, and others, are published in the same way; these and "Horses at Pasture" from nature, bespeak the high perfection of the process.

"Besides views from nature," says the circular, "and portraits from life, which collection will be increased from time to time, very accurate copies of classical engravings are in process of being taken. Objects from natural history and anatomy, as well as views of interesting machinery, the objects of art and industry, will be added. Persons wishing to have portraits from life transferred on glass for a magic-lantern slide, to enable them to show the different members of the families through that instrument, can have it done, and those living at a distance, by sending a daguerreotype portrait, can have it copied on the transparent material with the utmost accuracy."

When Le Gray, of Paris, first suggested that collodion might be rendered available in photography, and Mr. Archer, of England, carried out his suggestion practically, no idea could have been entertained of the stimulus this discovery would render to the progress of photography, which now figures as one of the large industries of the age. The first stimulus was the introduction of stereoscopic pictures, which at once found ready sale the world over. It was a long time before the makers could be induced to produce positives upon glass, knowing, as they did, that a negative could be produced from the positive, and the value of the original lost. They finally made glass stereoscopic positives, but it was soon found that they could be cut apart and the ground glass, or its substitute, removed, and thus made available for the lantern. Many, if not all, of the first slides used were stereoscopic positives cut in two, until finally a demand for lantern slides took the place of the stereoscopic positives, which are now curiosities and only found in a few collections.

Among the first to enter into the manufacture of lantern positives were Negretti

& Zambra, of London, for which they received from Austria, in 1862, the gold medal for the best stereoscopic glass slides and lantern pictures.

After these came Ferrier & Co., in about 1863. Then Levy & Lachenell, of Paris, who have long held a reputation for their beautiful pictures, all being produced on albumen dry plates The exact formula has never been divulged.

Among the celebrated English makers may be named Messrs. F. York & Son and Mr. W. England; Wilson, of Aberdeen; Valentine, of Dundee, and others; all of whom produce beautiful and artistic work.

In this country may be named the veteran photographer, Mr. Roche, so long connected with the house of E. & H. T. Anthony & Co., who has traveled more miles and produced more negatives than any other photographer in this country.

Woodburytypes.—These beautiful gelatine pictures, so well known to lovers of art, are interesting from the fact that they were the first and only practical photo-mechanical pictures that could be used with the lantern; and as great pains were taken to select good subjects to produce a negative, and care bestowed upon the glass positives, together with the low price at which they could be produced, gave them a wonderful degree of popularity and praise, which they justly deserved. Some of the finest illustrations that have ever appeared in art and natural history by any photo-mechanical process are Woodburytypes. They are printed from a lead plate in a hand-press, with thin gelatine, to which the pigment has been added, and are either printed upon paper or glass.

It is to be regretted that few, if any, of these pictures are now made in this country, on account of our climate not being suited to work in gelatine.

It is one thing to make a slide to please the amateur, for he is ready to award it a prize on its purely artistic merits, but let that same picture be offered to the trade, and it is at once subjected to a criticism that differs materially from one of art alone. It must be clear in the shadows; sharp, and well-defined; just of the right intensity to be used either with the oil or lime light; free from imperfections; of a good, pleasing, warm tone, with not too much sky or foreground; properly centered, with a diaphragm suited to the subject; covered with a clear glass of a certain thickness; bound on the edges with black needle-paper, lapping over only the one-eighth of an inch, and so fastened that the edges will not leave the glass. This is what the trade calls for.

When we can combine art and all these requisites together, then we have a perfect slide.

The great difficulty at present with most amateurs is quantity and not quality, for it is seldom that I see what I could call a perfect slide, and many are hardly worth the time of binding. Some possess a possible trace of artistic merit that, if carefully made, might yield better results. Unless possessed of all the above-mentioned points, they can never be classed as perfect pictures for lantern projections. I hope that the criticism that I have ventured may lead to a better class of transparencies than is usually to be seen at an amateur exhibition, for certainly the negatives produced are far in advance of many produced by professionals, and for that reason should yield better slides; although it is not always the best printing negative for paper that is suited for a lantern positive. Unless a negative is clear in the shadows, sharp and free from stain and color, it will be impossible to produce really satisfactory transparencies.

Mechanical slides include those to which motion is imparted either by slipping one glass over the other, or by a lever giving a circular movement to the picture, and are called slipping, lever and chromatrope slides. The latter consist of two disks of glass, brilliantly painted, with designs radiating from the center. (Fig. 20.) The disks are made to revolve in opposite directions by a ratchet movement communicated by means of a handle, producing many pleasing changes of design and color. The motion can also be imparted by means of bands instead of a rack. The silhouettes are only figures painted in sharp outlines, the other parts being opaque, or a figure can be attached to a glass slide. By means of mechanical slides many curious and interesting effects may be produced. The slipping-slide is used for a variety of scientific and astronomical purposes, but mostly for grotesque and comic effects, the construction of which can be understood from the accompanying cut. (Fig. 21.) In the case of the two combatants, the first piece of glass, when pulled out to its full extent, must hide the lower arms and swords, and when pushed into the frame must hide

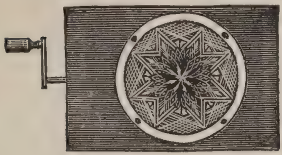


FIG. 20.—CHROMATROPE.

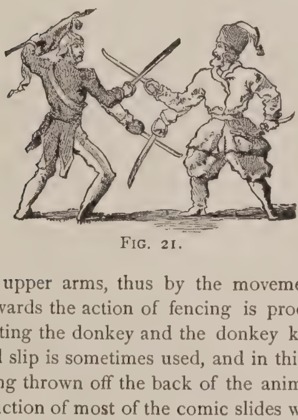


FIG. 21.

FIG. 22.

the upper arms, thus by the movement of the piece of glass backwards and forwards the action of fencing is produced. In Fig. 22 the action of the boy beating the donkey and the donkey kicking are given in the same way. A second slip is sometimes used, and in this case would produce the effect of the boy being thrown off the back of the animal. This is the general principle of construction of most of the comic slides which excite the mirth of the young, or perchance arouse in some degree the fears of youthful spectators. (Figs. 23 and 24.)

FIG. 23.

FIG. 24.

In order to prevent the paintings being worn by the action of the movable pieces of glass, strips of thick paper must be pasted between them to prevent contact.

Lever slides are used to produce a movement to the head and eyes of man or animals, giving them the appearance of vitality, or the rolling movements of a ship at sea. (Fig. 25.) Revolving effects are produced by having a circular piece of glass in a cogged frame, which is made to revolve by means of a rack and handle. This is used for astronomical slides, showing the revolution of the planets round the sun, sails of a windmill, or any similar action. With these useful slides, and a little ingenuity and taste, many agreeable and amusing effects may be produced.


FIG. 25.—LEVER SLIDE.

Slide-tinters, which are used for a variety of effects, such as sunsets, moonlights, and for statuary, are best made by using thin colored films of gelatine placed between two pieces of glass, or by flowing over the glass white shellac varnish in which is dissolved some soluble aniline color.

Outline drawings upon fine ground glass can be used, but the amount of light obstructed will hardly pay for the trouble bestowed upon them. A glass slide coated with a thin film of gelatine is found to answer the purpose much better. The drawing should be made in Indian ink, which in many cases will answer as well as a photographic positive.

It is not my intention in this place to give methods for making lantern positives, as that more properly belongs to photographic manipulation, to which the reader is referred.

Having prepared the reader to make a selection, if he so desires, of the numerous forms of the lantern, a few words in regard to its management will not be out of place; for, like all optical apparatus, it is necessary that some little practice be devoted to it to enable one to make faultless projections. And it is to be hoped that a more satisfactory result will be obtained than is to be witnessed at many public exhibitions, giving proof that the operator lacks knowledge in proper illumination, together with imperfect focusing, and the almost inevitable reversed or upside-down picture, which always provokes laughter and comment, all of which can be avoided by following carefully the simple instructions here given.

Before using the lantern see that the lenses are clean and free from haze, which is best removed by the use of a fine cambric handkerchief free from starch. Many use chamois skin, but, unless very carefully selected and free from grit, it is more likely to scratch than the cambric. Next select a good lime and place it firmly in the socket of the holder, after which turn on the hydrogen carefully, and then light it, at the same time turning the lime to prevent a fracture. After the lime is heated in this way, gradually admit the oxygen, adjusting one or the other gases until the lime is incandescent, not allowing the jet at any time to make a noise; and always remember that the *oxygen must be turned off first* when the light is to be extinguished, after which the hydrogen is turned off. When using gases from cylinders, be sure and set the stop-cocks down tight, for a neglect in this direction often leaves you without gas for the next exhibition.

The next and most important step is the centering or focusing of the light, for the manner in which an object is lighted is second in importance only to the excellence of the glass through which the light passes. These remarks are so true, that it is not too much to say that the power and perfection of the best modern lenses cannot be correctly estimated or fully appreciated unless employed

in conjunction with the best methods of illumination. The success of a proper illumination depends upon the incandescent lime being in the center of the condensers, so that the light will thus be able to pass through the axis. This position is to be found by moving the jet, which should be furnished with all the necessary adjustments, either up or down, backward, forward, or to the sides, until the field is free from bluish fringes or dark patches, which indicate that the lime or light is too near the condensers, while an orange color indicates that the lime is too far back.

These adjustments should be made without the use of a picture in the lantern, using the entire circle of light from the condensers. After the light is in its proper position or focused, and the field of light is clear and of a uniform white color all over the circle, then introduce the picture, bringing it in the center of the condensers, and focus by means of the thumb-screw on the objective.

The opening or mat on the picture should just cover the screen. But without the picture the circle will be much larger than the screen, and would reduce the size of the picture if we focused on the circle and not on the picture.

When using the accessory apparatus it is highly important that these directions be carefully carried out, for each attachment will require a certain position of the light to insure success.

The pictures should all be marked with a small gum ticket in the upper corner in such a way that when placed in the lantern they will appear in their proper position on the screen. This little precaution, simple as it is, will often prevent the operator being filled with mortification, and an audience and lecturer with displeasure, at the stupid management at the lantern; for what is more provoking than to see a picture first upside down; while if lettering is upon it, to have that read backwards, and at last after a third effort to come all right. No excuse can be given but total ignorance on the part of the operator for such blunders as this, occurring as they often do in public lectures and by parties claiming to have a knowledge of the lantern.

CHAPTER VII.

VERTICAL LANTERN—MICROSCOPE ATTACHMENT—SPECTRUM PROJECTORS.

These accessories include the vertical attachment, the microscope attachment, polarizing elbow, and spectrum projector. Each requires special adaptation to the lantern, a knowledge of which is essential to those aiming to make the study complete. Little skill is required to make ordinary lantern projections compared with that necessary when using the above accessory apparatus. For you must possess a certain knowledge of each subject that the attachments are used to illustrate to make perfect projections, and should at all times be able to detect faults in the working of the apparatus. The latter remark applies more especially to polarized light and spectrum analysis, as the success of these experiments depends upon careful manipulation, most of which is carried on in the dark. The hand therefore requires as much training as the eye, all of which can be accomplished by practice and a thorough knowledge of the apparatus.

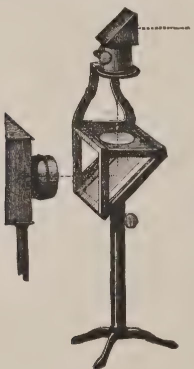


Fig. 26.

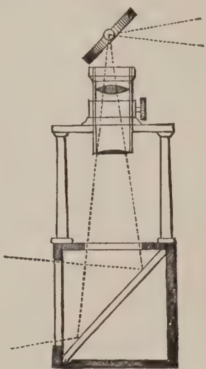


Fig. 27.

Vertical Attachment.—For a large class of experiments, both in chemistry and physics, it is important that the object remain in a horizontal plane, this led to the invention of what is called the vertical attachment, which was first introduced by Duboscq in 1868. It is curious to note that so celebrated an optician should have omitted to interpose a condenser between the mirror and objective, as is shown by the illustration (Fig. 26), which is copied from *Les Mondes*, vol. xxiv, page 650, 1870.

Edwin Smith constructed a vertical attachment, by means of which he was able to exhibit to a large audience the electrical phenomena in plants. This was in 1870, and was published in the *Chemical News*, February, 1870, page 90.

Professor J. P. Cooke, of Cambridge, Mass., made use of a vertical which differs in principle little from Duboscq's, and was used to illustrate lectures and project magnetic curves, an account of which is published in the *Journal of the Franklin Institute* for 1871, vol. lxii, page 408. (Fig. 27.)

Dr. R. M. Furguson constructed a simple vertical which can be readily put together, and is made mostly of apparatus found in the laboratory. The accompanying cut shows the arrangement, and was taken from the *Quarterly Journal of Science* for 1872, vol. ix, page 267. (Fig. 28.) It consisted of *L*, lens from lantern; *m*, plate-glass mirror at an angle of 45 deg.; *s s*, glass saucer; *l*, a lens; m_2, a second mirror to throw the light upon the screen. This apparatus, simple as it is, was used to illustrate a course of lectures on Sound in the Edinburgh Museum of Science and Art.

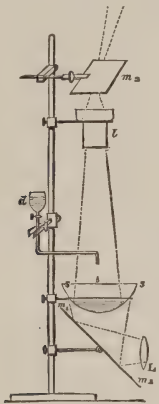


FIG. 28.

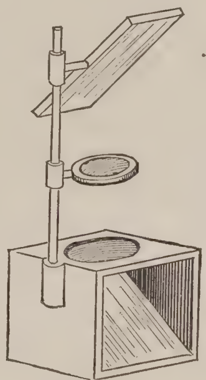


FIG. 29.

A simple form of vertical, which can be made cheaply, consists of a box holding a mirror of plate-glass, 6 x 6, placed at an angle of 45 deg., with a support for lens and second mirror to reflect objects upon the screen. With this vertical it is possible to produce results quite good enough for class demonstration. (Fig. 29.)

All these were imperfect in construction, and failed to give satisfactory results, and it remained for Professor Henry Morton to first separate the ordinary lantern condenser into two elements, one before and the other after the reflecting mirror, by which the efficiency of the instrument was greatly increased. The principle is that if we place first so much of the condenser as will bring to parallelism the rays diverging from the source of light, they then pass on to the remaining lens after reflection exactly as they would have done had the condenser occupied its usual position. It will thus produce a field evenly illuminated, and the beam is the same as without the vertical, covering the screen to the edges of the circle, and producing a picture sharp and well defined. (Fig. 30.) With

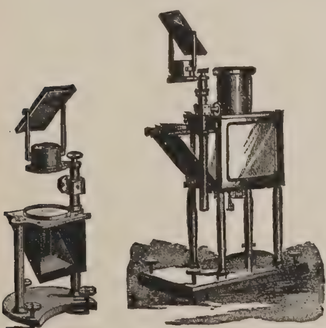


FIG. 30.

this apparatus it is possible to exhibit to a large audience many of the most beautiful experiments in the domain of physical science.

Microscope Attachment.—Much disappointment is often experienced in working with this attachment, and it is not to be wondered at when we stop to consider the character of the objects and their small size as compared with lantern slides; and before describing the apparatus, it will be advantageous for fixing in our minds its limits and possibilities, to carefully consider the following lines.

The amount of light proceeding from the small object is diffused over the relatively enormous surface of the magnified image. It is of the utmost importance that the object should be brilliantly illuminated if the image is not to be too faint. When we consider that the light on the slide is about half an inch in diameter, when we enlarge this to eight feet we have reduced the light to $\frac{1}{182}$ of the original power. But in fact the whole of the light is never transmitted, a considerable part of it being lost in various ways in passing from the object to the screen; hence the necessity for intense illumination is at once evident.

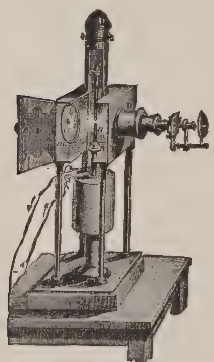


Fig. 31.—Electric Microscope.

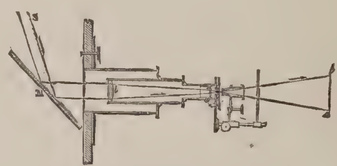


Fig. 32.—Solar Microscope.

Fig. 33.—Gas Microscope.

It is highly important that we should remember that the condensers also condense the heat rays as well as the light, and if the objects are exposed for any length of time they would be destroyed. This may be obviated by the interposition of certain media, which, while they are pervious to light, are impervious to heat. The most convenient medium is a strong solution of common alum; this is placed in a glass cell between the condenser and the object. The amount of light lost by absorption and otherwise is small, while the whole of the heat is stopped, making it possible to expose objects in the cone of the focus for an indefinite time without injury to the objects, many of which are mounted in balsam that melts at a low temperature.

While many books tell of objects being highly illuminated on a fifteen feet screen, I have grave doubts as to its accomplishment. Yet many highly interesting and instructive objects can be magnified in a very satisfactory manner; but the number is limited, as is the range of the apparatus; more especially with artificial

illumination than with sunlight, for this latter reduces the error to a small fraction. In fact I have made much better projections by means of sunlight with inferior lenses than would be possible with even the best selected lenses and artificial light.

The microscope attachment consists of a combination of an achromatic objective, with a suitable stage holder for the objects. This is screwed on to the lantern in place of the ordinary slide projector. The general arrangement will be gleaned from the illustrations. (Figs. 31, 32, 33.)

Some advise the use of achromatic condensers to produce a flat field, but for my part I have never been able to detect any great advantage. Others again use low powers and amplify by means of a second objective. In all these cases the diminution in the light is so great as to preclude their use.

The powers best suited are $1\frac{1}{2}$ inch, 1 inch, $\frac{1}{2}$ inch, with possibly $\frac{3}{10}$. They should be made especially for this purpose, and admit as much light as possible with a flat field and good definition to the edges, and it is at this point that we are apt to meet with some disappointment, as a flat field and good definition is a matter yet to be settled by the optician, and as the demand for objectives for the gas microscope is limited, it is not to be expected that any very great improvements are to be looked for in this direction, as the instrument has but a limited application itself. In most cases enlarged micro-photographic negatives are used to produce slides for use with the ordinary lantern, and in this way are made to yield far more satisfactory pictures than to enlarge the objects direct with the gas microscope. And in many cases a slide that could be used to produce a good negative would be entirely unfitted for direct projection. It is necessary that the objects should be carefully selected, and the powers of the objective arranged to suit them.

The objects best suited are parts of whole insects, such as the eye or proboscis of a fly; thin sections of wood, rocks, and crystals of various salts are admirable objects. Live aquatic insects are placed in small glass troughs or life slides containing water. The circulation of the blood in the veins of the distended foot of a frog can also be shown.

The light will require constant attention, and should be forced to its utmost intensity without hissing, and the jet will have to be drawn back so that the cone of light shall impinge upon and cover the slide or object.

It is not desirable in any case to push the magnifying power too far, for the illumination of the image in that case becomes very faint, and if there be any cause of aberration in the lens, whether spherical or chromatic, its effects will be rendered more apparent.

A convenient way of attaching the apparatus to the lantern, as designed by the author, is by means of a hinge on one side of the lantern, so that it may be swung out of position and be replaced by the ordinary objective, which is hinged to the opposite side. This will be found a great convenience, as many times a picture can be projected and in an instant the microscope attachment replaced, thus doing away with the use of two lanterns.

During the siege of Paris, the gas microscope was used to enlarge microscopic photographs of voluminous dispatches, which were reduced to a few square centimeters and conveyed by carrier pigeons. When the dispatches reached Paris they were enlarged by the gas or electric microscope, and a copy was then made

of their contents. This was certainly a most useful and ingenious application of photo-microscopy. (Fig. 34.)

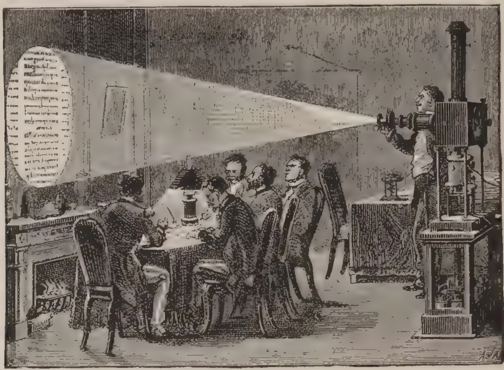


FIG. 34.

Spectrum Projector.—Satisfactory results in spectrum analysis are arrived at only by the use of the electric light. Fairly good effects can be produced to show the decomposition of light by the use of the lime light, but when intending to use the apparatus for spectrum analysis, it becomes necessary to have the electric arc to volatilize the metals used.

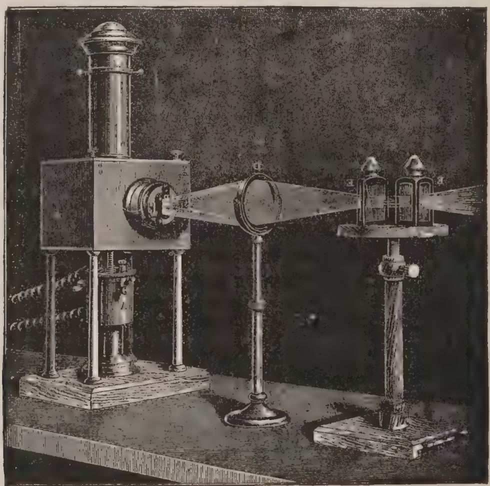


FIG. 35.—SPECTRUM PROJECTOR.

The apparatus used for spectrum projections consists of the usual form of lantern, with the achromatic objective removed. Close to the condensers is fitted

an adjustable slit. On a stand is mounted an uncorrected plano-convex lens of about 12 or 14-inch focus, and on a second rigid stand are mounted two large prisms filled with bisulphide of carbon, these being used to get larger dispersion for a given distance than that produced by glass prisms. The whole apparatus is mounted upon a solid base, which can be rotated through an angle of 90°.

The light from the lantern passes through the narrow vertical slit, and by means of the lens D a distinct image of the slit is produced upon the screen. The prisms filled with bisulphide of carbon are now introduced upon the stand at a distance of about 18 inches from the lens, and the light allowed to pass through them, and at once a beautiful and lengthened spectrum falls upon the screen.

In the spectrum there are an infinite number of tints which merge into one another by insensible gradations, but we usually call them the seven prismatic colors: red, orange, yellow, green, blue, indigo, violet. The violet is the most refrangible and the red the least; the violet occupies the greater portion of the spectrum, the orange the least. To secure the best results the prisms are adjusted to the angle of minimum deviation for the yellow rays. The entire apparatus as mounted for use is shown in Fig. 35.

Since the introduction of spectrum projections, a great inconvenience has been felt by lecturers being compelled to use two lanterns, one for the exhibition of the spectra, the other to project a slide or other object.

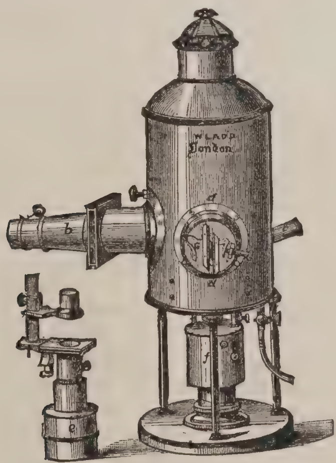


Fig. 36.

When only one lantern is used it is necessary to disconnect the apparatus, and revolve the lantern in order to bring the object on the screen. It is inconvenient to show all the spectrum experiments together, and diagrams, etc.; afterwards, the loss of time in getting the prisms and lenses to their required position, and readjusting the lantern, is considerable. These inconveniences Mr. Ladd has entirely overcome by his new form of lantern (see Fig. 36), which is provided with two openings —one placed facing the screen, and the other at an angle of about 100 deg. from

it, this being about the proper angle when two prisms containing bisulphide of carbon are used for producing a spectrum. But as the angle must vary, according to the distance from the screen, one of the openings is provided with an adjustment for that purpose. The lantern is also provided with a small opening at the back, at the same height as the other two, for the reception of a sliding tube, carrying a lens at one end which focuses on a piece of ground glass, at the other, an image of the carbon points. This enables the operator not only to see what is going on at the points, but also to keep them at an exact height, so requisite in many experiments. As an example of the utility of this arrangement, we will suppose the operator wishes to project on the screen an image of the arc as well as the spectrum of any particular substance; to do this he closes the slit, and focuses the arc by means of the optical arrangement facing the screen, and while the metal is still burning he closes this opening and opens the slit, when immediately a spectrum of the substance appears in the same part of the screen. The lantern is entirely of metal, and is also provided inside with a gas-jet and stopcock to enable the operator to perform his work in a darkened room.

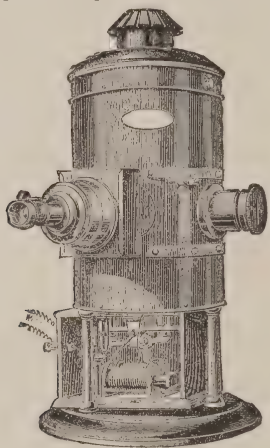


FIG. 37.

A convenient form of lantern, as designed by Browning, of London, is shown in Fig. 37, in which is attached the slit for spectrum projections and the ordinary objective for slide projection, and as the lantern is turned at an angle for the light to enter the prism through the slit, the objective comes directly opposite the screen.

In place of the bisulphide of carbon prisms there can be used a diffraction grating, which is a series of ruled lines upon glass or metal—from 15,000 to 75,000 lines to the inch. They have a much greater dispersive power than a glass prism, and produce a normal spectrum.

Another form of prism, known as the Thollon, is an important improvement in spectrum projections. It consists of a dense glass prism of 90°, with two additional prisms cemented to it. It has the great advantage of being direct vision, and does not require the lantern to be turned at an angle, and its dis-

persive power is even greater than the bisulphide of carbon. The only drawback to their general introduction is the price, which is much greater than glass or hollow prisms.

With the electric light it is important that the carbon points should be at a proper distance from each other, and to carry out this design many pieces of apparatus have been invented, which are known as regulators, and are divided into hand, clock, or magnetic, or both.

Of the many designs that are to be found, there are only a few which automatically approximate the points in proportion as they are burnt away, at the same time maintaining the carbons in the axis of the condensers. The consumption of the positive is much more rapid than the negative, and to overcome this

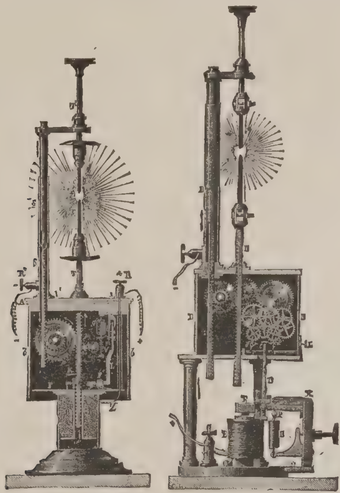


FIG. 38. DUBOSCQ'S.

FIG. 39. FOUCAULT'S.

difficulty, Duboscq and Foucault constructed masterpieces of mechanism, which are shown in the Figs. 38, 39. A detailed account of each would be out of place, as it can be found in all works on physics. By means of either of these regulators it is possible to keep at an equal distance the arc of flame unbroken for hours.

A hand regulator can be cheaply made by a simple device to give an up and down movement by means of a ratchet to which the carbons can be attached, and for most experiments is all that can be desired.

When projecting the spectra of the metals, the lower carbon should be somewhat larger than the upper one, and hollowed out that the metal will not roll away when melted. In some cases several of these carbons are mounted upon a metal disk, which can be rotated, thus changing without stopping to remove the lower carbon. As the greatest heat is required at the lower carbon, the positive wire must be connected with it. Unless this precaution is taken, the metal is liable to jump and spatter, in some cases destroying the experiment. When

required to produce the light only, the upper carbon is always connected with the positive current, as the transfer of the particles is from the positive to the negative pole. The most striking metal to project is silver, for at the instant the current passes through the carbon electrodes, the little globule of the metal is quickly converted into a beautiful green vapor, which exhibits the best set of bands of all the metals. Other metals, as copper, zinc, lead, mercury, and in some cases the salts of the metals, can be used.

It is impossible in this connection to go farther into details, since the subject is beyond the limits assigned to this treatise. For further information the reader is refered to Prof. Roscoe's and Dr. H. Schellen's Lectures on Spectrum Analysis.

CHAPTER VIII.

ATTACHMENTS FOR POLARIZED LIGHT.

Light which has been refracted from certain surfaces, or transmitted through certain substances under certain special conditions, assumes new properties, and is no longer reflected, refracted or transmitted, as is ordinary light. This change in the action of light is called polarization, and rays thus modified are said to be polarized. This phenomenon was discovered in 1808 by Malus, a young engineer-officer of Paris.

According to the undulatory theory, a ray of common light contains vibrations in all planes passing through the ray. In polarized light the vibrations are reduced to one plane only. The term polarized, as applied to light, is an unfortunate one, but it is too firmly engrafted upon science to be changed for a better name, and we are still obliged to use it. It originated from the analogy of two ends of a magnet, which consist of poles; and as the beam of light was said to have sides and ends, it was called polarized. Strictly and scientifically speaking, it is light vibrating in one plane.

Fig. 40.

There are four principal methods by means of which a beam of light may be polarized: they are, *reflection, ordinary refraction, double refraction, and absorption.* Two of these methods only can be used practically for purposes of projection with the lantern: they are double refraction and ordinary reflection. Any instrument used to polarize light is called a polarizer, and the instrument to examine the light polarized is called an analyzer, and either may be used to polarize or analyze. A large number of crystals possess the property of double refraction—that is, a ray of light in passing through a double refracting crystal is divided into two rays—hence an object seen through one of these crystals appears double (Fig. 40). Such a crystal possessing this property to a high degree is Iceland spar, and if we look at a dot or letter or line, a double image will be perceived, as two dots, two letters, two lines, etc. Now, the light in passing through is divided into two rays, one of which is called the ordinary, the other the extraordinary ray, and both are polarized. The ordinary image will seem slightly nearer to the eye than the extraordinary, and if the crystal be turned round, the ordinary image will continue fixed, and the extraordinary will describe a circle around it.

The objection to the use of a natural rhombohedron of Iceland spar, is that it gives two rays, one of which must be suppressed. This was most perfectly accomplished by the invention of the Nicol prism, which is made by cutting a rhomb of Iceland spar along a diagonal plane, and then cementing the two pieces together in their natural position by Canada balsam, whose refractive index is intermediate between the ordinary and extraordinary indices of the crystal. A ray of common light suffers double refraction on entering the prism, but the ordinary ray is totally reflected on meeting the first surface of the balsam, and is thrown to one side, while the extraordinary ray passes through the balsam, and emerges at the end of the prism parallel to the original ray (Fig. 41). The lateral faces of this compound prism are all painted black, leaving only the terminal faces for the transmission of the light. The ordinary ray suffers total reflection, and is absorbed by the blackened side of the prism.

FIG. 41.

The Nicol prism is the most valuable means of polarizing light; yet, while it more perfectly polarizes the light than the bundle of glass plates, it produces a small beam or circle, which is not governed by the distance of the lantern from the screen, but by the size of the prism. To secure total reflection of one ray, its length must be considerably greater than its breadth, and this necessarily limits the divergence of the transmitted beam; yet by its use you get a colorless pencil of light, perfectly polarized, from 20 to 27 degrees in breadth.

With the use of the Nicol prism as the polarizer, the lantern is parallel with the screen, which has some advantages.

Large pieces of Iceland spar are scarce and very difficult to obtain, and for this reason other methods are used to polarize the light; and next to the Nicol prism in efficiency is the Foucault prism, which differs from the former in employing a film of air instead of Canada balsam, and the two halves of the prism being about one-third as long as the Nicol. The objections to its use is that it has a less angular field, and the light used must be parallel, while there is a large loss of light by two reflections. (Fig. 42.)

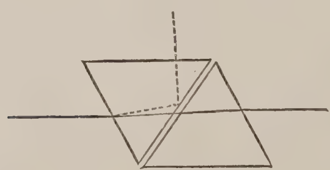


FIG. 42.

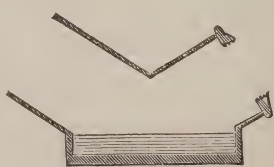


FIG. 43.

The third method is by means of single reflection with a bundle of glass plates set at an angle of 56 degrees, that being the angle of polarization for glass. (Fig. 43.) The plates of glass used should be about one-twentieth of an inch thick, fifteen to twenty in number, of good quality, and about 5 x 8, or large enough to receive the full beam of parallel light from the condensers. The plates are mounted in a metal frame or elbow, which is firmly attached to the front of the lantern. Fastened to the front of the elbow, or on a separate stand, is placed a plano-convex lens and a small Nicol prism about

three-quarters of an inch across its longest diagonal. A smaller one can be used, such as comes with the microscope, and will yield fairly good results. The Nicol, thus termed for the sake of brevity, must be so mounted in front of the lens, and be so placed in the focus, that all possible light may pass through it; and by fitting it into a collar it can be rotated. (Fig 44 N.)

The great advantage of using the bundle of plates is, that it gives a beam of light the size of which depends upon the distance from the screen, the same as in ordinary lantern projections, and the cost of the apparatus is much less than with the use of two Nicol's.

The objection to the use of the bundle of plates is, that as the lantern must be turned at an angle, a large amount of light is lost by absorption; only one-half that is used is reflected, and this in passing through the analyzer is reduced to about 15 per cent. of the original light.

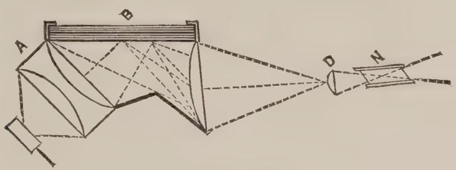


FIG. 44.

When using either of these attachments, it is important that the light should be carefully adjusted and made to yield the greatest possible illumination. The plates must be perfectly clean and dry and the outside glass should be covered with black cloth or varnish. The experiments are of the most fascinating character. Many of the objects are prepared from mica or selenite (sulphate of lime), which is an easily procurable crystal, readily cleavable into thin laminæ capable of showing the colors of polarized light, and is most frequently employed in experiments on chromatic polarization.

Making use of the principle that the color produced depends upon the thickness of the plate, selenites have been cut of suitable shapes and thicknesses so as to produce colored images of stars, flowers, butterflies and other objects, which appear transparent to the eye, but yield the most gorgeous and indescribable display of complementary colors as the analyzer is made to revolve.

If the object or films be rotated while the polarizer and analyzer remain fixed, the color will appear at every quadrant of revolution and disappear at intermediate positions. When the Nicol is rotated, the colors will change to the complementary at every quadrant; that is the same color will be seen in positions of the analyzers differing 180 degrees, and the complementary will be seen at 90 and 270 degrees.

These methods yield plain polarized light. There are two other forms, elliptical and circular, each of which require additional apparatus, such as a quarter-wave plate or two Fresnel's rhombs, for a full description of which the reader is referred to "Ganot's Physics;" "Daguin's Traite de Physique;" "Jamin's Physique;" "Polarized Light," by William Spottiswoode, F. R. S.; "Brewster's Optics;" Pereira's "Lectures on Polarized Light;" Lewis Wright's "Light."

When projecting the larger objects, they occupy the same position in the lantern as the ordinary slide, but by far the larger number of objects are those used with the table microscope, and to project these requires the microscope attachment, which has already been described. It is placed in front of the elbow and the Nicol is placed in front of the objective. The entire apparatus is shown in Fig. 45. With this combination it is possible to project many beautiful and highly interesting objects and study them on a large scale.

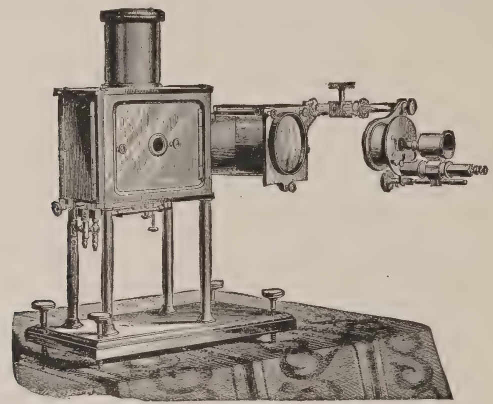


FIG. 45.

The large objects best suited, besides the designs already mentioned, are—

Plates of selenite, giving tints red and green.
" " " " yellow and blue.
" mica, tints red and green.
" " " yellow and blue.
" quartz cut parallel to the axis, thin.
" " " " " thick.
" " " oblique, giving hyperbolas.

CHAPTER IX.

A NEW APPARATUS FOR THE OXY-CALCIUM LIGHT.

Although the preparation of oxygen at the time of consumption has from time to time been suggested, little attention has hitherto been given to this matter. Feeling that there was both room and need for a simple and practical method of generating oxygen as required for use in the lantern, I have been prompted to give the matter some little investigation.

The problem sought after in the construction of the apparatus to be described, resolved itself into an economical, efficient, durable, simple, and withal cheap and portable apparatus for the production of the oxy-calcium light. This is a long felt want for use in enlarging upon gelatino-bromide paper, and in the lantern for the projection of pictures with an illumination far greater than that produced by any oil light. While not claiming originality as a whole, I have rather correlated ideas and materials and put them into practical working order.

Some have unjustly laid claims to the invention of heating oxygen mixture in tin or metal tubes. I have taken pains to secure abstracts and references which I hope will set aside all doubts and give the honor to whom it is due.

The old method for the preparation of oxygen consists in mixing the ingredients and heating the same in metallic retorts, disengaging the entire amount of oxygen contained in the mixture at one heating. This necessitates the use of a large rubber bag or suitable receiver to hold the gas.

The first account I found of doing away with the gas bag was suggested by Mr. Noton, an Englishman, in 1868, by using several small retorts or tubes in which was placed plugs or cakes of the oxygen mixture, which could be heated and the gas disengaged in small quantities at a time. This apparatus was modified by Mr. Chadwick, and is now manufactured and sold in London.

In 1870, Dr. Andrew Smith published an article entitled "Oxygen Gas as a Remedy in Disease," in which, after describing the many methods that can be made to yield the gas, describes and pictures a piece of apparatus in which the mixture of potassic chlorate and manganese dioxide is heated in a metal tube by means of a Bunsen burner or alcohol flame, heating only a portion of the tube at a time, generating the gas in small quantities, depending upon the amount of tube heated. This apparatus was manufactured and furnished to physicians for the preparation of oxygen, in 1877, by Mr. Beseler, of New York.

The apparatus devised by the author, as shown in the cut, consists of a long tin or metal tube for heating the oxygen mixture, a small holder to produce a uniform pressure, and a blow-through jet. The gas-holder is not designed as a reservoir, and is used only to produce a uniform pressure, and for that reason is small. That the weight might be reduced and the space utilized for packing, the holder has an inside drum with only a half-inch water space.

The tube for heating the mixture is made of tin-plate or sheet iron closed at one end. The other end has a tapering plug of brass, in the center of which is a delivery tube; this plug is driven slightly into the tube, and the whole is perfectly tight. It is heated by a Bunsen burner or alcohol lamp, beginning at the end nearest the delivery tube or plug.

The gas will be given off slowly, passes into the holder and thence to the jet. As the holder descends, the flame of the burner is moved along the tube an inch at a time, thus keeping up a supply only as fast as the gas is consumed, and making it possible to generate gas for a few moments; or, by continued heating of the tube, to make enough for one hour's use.

If required for longer use, the tin tube can be replaced by one containing a full charge of the oxygen mixture. In this way the supply can be maintained for many hours.

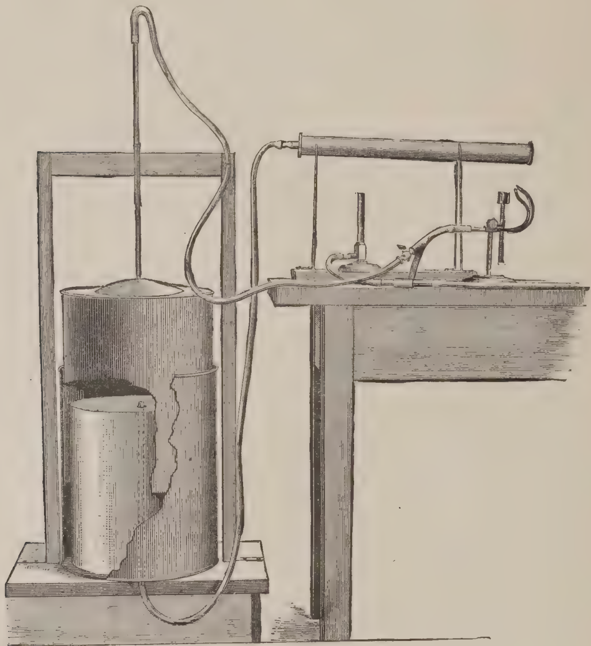


FIG. 46.

Where house gas is not available, the ordinary oxy-calcium jet with alcohol can be used. With this apparatus all danger of an explosion is avoided, and it can be used at a moment's notice, either to produce the oxy-calcium light, or to show experiments in oxygen; and also for the use of the physician. The only adjustment necessary when used for the oxy-calcium light is that the house gas is regulated by a stop-cock at the jet, the oxygen being regulated by the opening in the jet, and the pressure on the gas-holder.

The illustration (Fig. 46) shows the apparatus set up for operation, and needs no explanation.

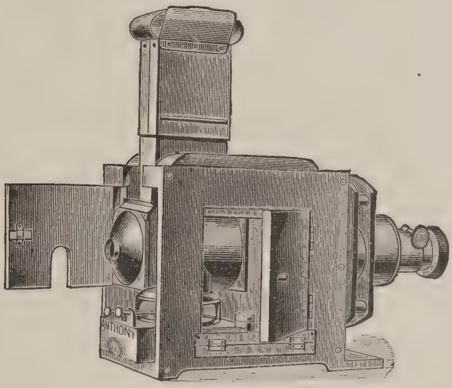
This light when used in the lantern will illuminate a circle twelve feet in diameter; gives a clear white field; and is in the optic axis of the condensers.

ANTHONY'S TRIPLEXICON,

A NEW AND SPLENDID

MAGIC LANTERN.

We have seen many lanterns in our time, but in several respects this eclipses them all, especially of those for use with kerosene oil only. The lamp itself is completely shielded with a well made hood of Russia iron, and is provided with the patent triplex wick, which affords the utmost illumination obtainable with any oil light. The back and front of the hood are closed interiorly by glass plates, specially annealed to withstand extreme heat, and the rear one is again closed by perforated sheet iron covered interiorly with a highly polished metallic reflector, back of which is inserted an eye-piece of ruby glass. The latter enables one to always observe the condition of the



flame and wicks, and regulate them, without disturbing or discontinuing the action of the instrument. The chimney is made telescopic, to pack more compactly.

The diffusing lens, specially constructed for the purpose, is mounted on a cylindrical slide, to extend, if necessary, the focal distance, while the condensing lenses, which are of four inch diameter and can be separated for cleaning, are inserted in a corresponding slide within the wooden case.

The case itself is quite compact, and appears very ornamental in its highly polished mahogany, with its little hinged ventilators on either side at the bottom. The metal front is burnished and has a spiral spring adapter for the admission of the slides. A substantial wooden box contains all, and serves also as a table for the instrument while in use. Altogether this is the finest example of its kind we have yet seen. It will also serve admirably for enlargements with the gelatino-bromide paper.

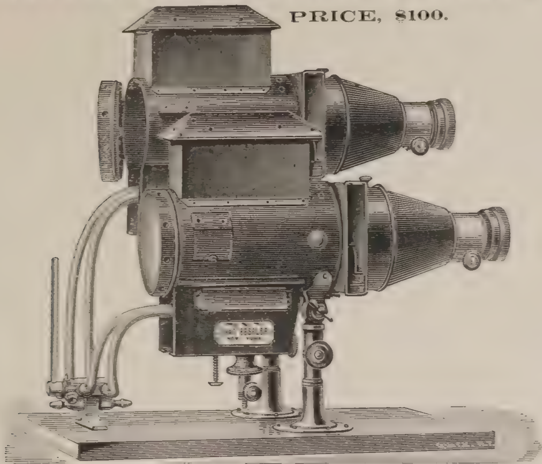
It is destined to become very popular.

PRICE, ONLY $40 00

E. & H. T. Anthony & Co.

THE BESELER OXY-HYDROGEN STEREOPTICON.

PRICE, $100.



THIS Stereopticon consists of two well-ventilated tubular lanterns $4\frac{3}{4}$ inches diameter, made of Russian sheet iron, with all seams folded and riveted, and nicely japanned in imitation of black rubber. With hinged doors at the side and back of each lantern; first quality condensing lenses, $4\frac{1}{2}$ inches diameter; superior $\frac{1}{4}$ size achromatic objectives, nicely mounted in brass with rack and pinion adjustment for focusing; improved oxy-hydrogen compound jets, warranted to burn entirely noiseless, and new device for regulating the lime cylinders and for adjusting the position of the jets; latest improved dissolving key, warranted not to darken the screen and arranged to be used with compressed gases direct from cylinders.

The instrument is provided with swing joints, rotating on plated pillars fastened to a walnut base.

The cut represents the Stereopticon when set up for immediate use. For packing and for economizing in space by removing the extension pillars from the upper lantern, both lanterns are brought on a level.

The great advantage of a Stereopticon of this kind is, that the operator may remain at one side of the instrument, not being compelled to walk around the same in order to arrange the views properly.

The $\frac{1}{4}$ size objective will produce a brilliant and well-defined picture of any desired size up to 25 feet diameter.

Refer, by permission, to a few parties using my Magic Lanterns.

AMERICAN MUSEUM OF NATURAL HISTORY, CENTRAL PARK.
(77th St. and 8th Ave. , NEW YORK. Nov. 3, 1884.

Having examined many kinds of Stereopticons that have been offered at moderate prices, we have selected Mr. BESELER'S as the best for the price, and have purchased them only. ALBERT S. BICKMORE.

I indorse the above, and from a thorough practical knowledge can recommend them to any one in need of a first-class instrument. L. C. LAUDY, Operator, Lec. Dept. Amer. M. Nat. History.

Prof. P. W. BEDFORD, College of Pharmacy, New York City.
Dr. L. H. LAUDY, School of Mines, New York City.
SAM. F. JONES, Attorney at Law, J. C. TAYLOR and J. C. HILLS, Hartford, Conn.
Prof. S. H. ALBRO, Fredonia, New York.
Prof. E. W. RUNYON, College of Pharmacy, San Francisco, Cal.

The Beseler Magic Lanterns are used by all the Normal Schools in the State of New York.

CHAS. BESELER,

218 CENTRE STREET, NEW YORK.